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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

PRODUCTS

PIPENET™ is the leading fluid flow analysis software of its kind. It is used all over the world by engineers, designers and consultants, in large and small organisations for a wide range of applications.

PIPENET™ is fast, reliable, versatile and an exceptionally well-proven system. A number of the largest PIPENET™ customers have standardised on the system for use through their organisation. In some applications it is the defacto industry standard. Regulatory authorities accept PIPENET™ calculations as meeting the mandatory requirements, and use it themselves for auditing purposes.

PIPENET™ has been accepted as meeting the TQA standards of several of its large multi-national customers.

PIPENET™ Standard Module

The PIPENET Standard Module is a powerful tool for the design of general steady flow of fluids in pipes. It provides a quick and cost-effective means of designing real life problems.

PIPENET™ Spray/Sprinkler Module

The PIPENET™ Spray/Sprinkler Module is exceptional for the design of fire protection systems. It can be used to design deluge, ringmain, sprinkler and foam solution systems for offshore platforms, refineries, petrochemical and chemical plants.

PIPENET™ Transient Module

The PIPENET™ Transient Module provides a speedy and cost-effective means of rigorous transient analysis. It can be used for predicting pressure surges (water and steam hammer), calculating hydraulic forces necessary for pipe stress analysis or modelling control systems in flow networks.

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SERVICES

To ensure that customers obtain the maximum benefit from the use of PIPENET™ products, Sunrise Systems offers the following services.

Documentation

All PIPENET™ modules are supplied with comprehensive documentation which includes:

- Tutorials
- Worked Examples
- User Manuals
- Technical Manuals
- Demo CD-Roms

Training

While PIPENET™ is easy to use even for those without prior experience, training courses are available to help users get the most out of the system.

The training courses include:

- Basic principles of network design
- How to use PIPENET™ to its maximum effectiveness
- Solving practical examples

Training courses can be held at Sunrise Systems or at the customer premises, and can be tailored to meet individual needs.

Support

All PIPENET™ products are fully backed up by our engineers and the customer support team.

Hot line support in the use of PIPENET™ is available either direct from Sunrise Systems or from our authorised distributors. If you need help with any aspect of PIPENET™, please do get in touch with us.

You can contact us by:

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LATEST NEWS

This is where we announce latest PIPENET™ news and releases.

Latest PIPENET™ Releases

As a reminder, All PIPENET™ Modules are fully 32-bit Windows 95/98/NT applications. If you have changed to Windows 95, 98 or NT recently now is the time to upgrade!

Standard Module Version 3.23

- Improved control valve modelling.
- Hydraulic grade line data is provided in the browser output if this option has been selected in the calculation options and the output tables.
- The pump/fan processor now allows up to 20 points to be used when defining the pump curve.
- Amendments have been made to ensure that the correct K-factor is displayed via the K-factors button in the duct properties dialog. Although an incorrect value could have been displayed, the correct value was used in the output of the calculator.
- The limit for the number of control valves has been increased to 600.
- The limit for the number of different tags has been increased to 600.
- The limit for the total number of pump/fans and filters has been increased to 350.
- A number of other minor improvements and corrections have also been made.

Spray/Sprinkler Module Version 3.23

- The pump/fan processor now allows up to 20 points to be used when defining the pump curve.
- Amendments have been made to ensure that the correct K-factor is displayed via the K-factors button in the duct properties dialog. Although an incorrect value could have been displayed, the correct value was used in the output of the calculator.
- The limit for the number of control valves has been increased to 600.
- The limit for the number of different tags has been increased to 600.
- The limit for the total number of pump/fans and filters has been increased to 350.
- A number of other minor improvements and corrections have also been made.

Transient Module Version 5.14

- The default type for all valves is now Cv flow coefficient instead of K-factor.
- A Two-Node Caisson has been introduced. This behaves like the existing Caisson (which is still included), except that it behaves like a Short Pipe when it is full. The simulation does not stop when the Caisson is full.
- The user is prompted to save all unsaved files before doing a calculation.
- Default filenames are provided for all the output files if the *.dat file has been saved before doing a calculation. This facility does not override any user's choices.
- A Graph Data File (*.res) is now generated by default whenever Output Graphs are selected. The default output timestep for the Graph Data File (*.res) has been made application dependent.
- PID Controllers and Transfer Functions are now set to the correct type depending on the component they are connected to. This only applies if the components are added using the Schematic.
- When adding a Specification to an Info Node, the default type is now Information. This only applies if the components are added using the Schematic.
- When printing the schematic the print dialog now includes the option to print to fit page.
- A facility has been added to the options toolbar to provide a default tag to be used for the creation of new components.
- The Area Tool will now move both nodes and waypoints, and will retain the snap-to-grid option. Nodes and waypoints that were on a grid point prior to the move will still be on a grid point after the move.
- Most component related limits have been increased.
- A number of other minor improvements and corrections have also been made.

For any queries about upgrading email support@sunrise-sys.com

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NEWSLETTERS

PIPENET™ NEWS

Sunrise Systems' Newletters provide overviews of new Pipenet™ product releases, case studies, frequently asked questions and other news. Features which are specific to each newsletter are summarised below.

Click on 'Download File' to download the newsletter.

All of our newsletters are available in Adobe Acrobat (pdf) format. If you don't have Acrobat Reader on your computer you can download it for free by clicking on the button to the right.

Volume 1 - Issue 5
February 2002
Download File

File Contents:

- Standard Module 3.23
- Spray Module 3.23
- Transient Module 5.14
- An introduction to specifications
- Pipenet™ and Windows XP
- Case Study: the use of Pipenet™ in modelling pressure surges and leaks in subsea and onshore pipelines
- Steve Horn
- New web page

Volume 1 - Issue 4
October 2000
Download File

File Contents:

- Transient Module 5.10
- Upgrade patches
- Development of the new user interface
- Case Study: floating platform offshore seawater system surge analysis using Pipenet™ Transient Module
- Case Study: ventilation system on a nuclear facility model using Pipenet™ Standard Module

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Volume 1 - Issue 3
December 1999

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File Contents:

- Standard Module 3.10
- Spray Sprinkler Module 3.10
- Transient Module 5.00
- Case Study: fire fighting system model using Pipenet™ Transient and Spray Sprinkler Modules

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Volume 1 - Issue 2
May 1999
Download File

File Contents:

- Standard Module 2.05
- Spray Sprinkler Module 3.00
- Transient Module 4.10
- The schematic option
- Case Study: water injection system model using Pipenet™ Transient Module

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Volume 1 - Issue 1
July 1998
Download File

File Contents:

- Standard Module 2.02
- Spray Sprinkler Module 2.02
- Transient Module 4.01
- Year 2000 compliance

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INFORMATION REQUEST

Use the form below to tell us what you think about our website, company, products, or services. Please also provide us with your contact information in the spaces provided.

Title:	Mr.
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SUPPORT / FAQS

Outlined below are some commonly asked questions about using PIPENET™ products. We hope this section will prove useful to our users when using PIPENET™ products.

General Category

Q 1: Having used blocked pipes in a network, I get the following error messages: 'Error in Equation n' or 'This network cannot be solved'.

Q 2: What does it mean if I get a node height error when I perform a check or a calculation? And what can I do about it?

Q 3: How can I simplify the use of the schematic with large networks?

Q 4: Why does the calculation for my network fail to converge or why is the solution not what I expected?

Q 5: Why when I select the Help option is no help displayed?

Q 6: I set the required number of specifications in accordance with the specification rules in the manual. A check on the status of the network suggests that all components are adequately specified. However, when I perform a calculation it fails with the error "This network cannot be solved. Please check your network or specifications".

Q 7: After installing the PIPENET™ module and inserting the security key I get an error message stating that the security key is not present.

Q 8: How can I model a leak using PIPENET™?

Q 9: How can I model blocked pipes in PIPENET™?

Q 10: What are NPSH and Cavitation Parameter and where can I find out more?

Q 11: In the Transient Module, why do I need to enter a Suter Curve for a turbo pump?

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LEADING THE WAY IN FLUID FLOW ANALYSIS

WELCOME TO SUNRISE SYSTEMS LIMITED

Sunrise Systems is a hi-tech engineering software company based in Cambridge. Our team of professional scientists and engineers who form the company are dedicated to nothing but the highest quality PIPENET™ products.

PIPENET™ is a powerful software tool for the engineer who needs to carry out fluid flow analysis on a network of pipes and ducts quickly and reliably. Whether the engineer is troubleshooting an existing system, or designing a new system from scratch, practically any flow analysis problem can be solved using PIPENET™. Extensive data checking minimises wasted time, while the proprietary calculation engine at the heart of all PIPENET™ modules ensures reliable results.

PIPENET™ runs under Microsoft® Windows™ operating system. Networks can be created using either text input or schematic. Interactive data entry through pull down menus, dialog boxes. etc. makes PIPENET™ easy to use.

The calculation output has been carefully designed to be logical, comprehensive and easy to read. The output can be saved in Word™ and Write™ formats making text processing and incorporation into design reports simple.

All PIPENET™ Modules, i.e Standard, Spray/Sprinkler and Transient, now come with a schematic facility allowing users to enter and edit networks via a graphical interface. The schematic capability can be used either as a visualisation tool, with text entry for the network details, or as the normal method for entering and editing networks. For more details see Latest News.

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RELATED LINKS

The products of Sunrise Systems interface with a number of software packages from other vendors to provide a complete solution to our clients. Here we provide links to some of the vendors of software packages that our client base have found useful.

If you would like to suggest a link to add to this page please Contact Us.

Hyprotech	Hyprotech is a leading supplier of modeling and simulation software and services to the continuous and batch processing industries, including air separation, chemical, gas processing, petrochemical, pharmaceutical, refining and upstream. Hyprotech modeling and simulation solutions significantly improve engineering productivity, efficiency and creativity.
Chemstations	Chemstations, a leader in process simulation software, has been developing and delivering powerful solutions to the process industries since 1988. Currently, over 1,000 companies worldwide use Chemstations' technologies to improve their productivity and increase their profitability..
COADE	COADE's products include CAESAR II, the industry's de facto standard for pipe stress analysis and design; PV Elite and CODECALC for pressure vessel design and analysis; CADWorx, an integrated series for piping and plant design/drafting and automation; and TANK, a comprehensive program for designing and analyzing oil storage tanks.
Peng Engineering	Software packages for piping stress analysis: SIMFLEX-II, SIMFLEX.S, SIMFLEX.Q
WinSim Inc.	DESIGN II for Windows - Rigorous Process Simulation for Chemical and Hydrocarbon Processes including Refining, Refrigeration, Petrochemical, Gas Processing, Gas Treating, Pipelines, Ammonia, Methanol and Hydrogen Facilities

NFPA	The mission of the international nonprofit NFPA is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating scientifically based consensus codes and standards, research, training and education

TOP

PIPENET™ NEWS

Leading the way in fluid flow analysis.

Volume 1 - Issue 5 February 2002

Editorial

Sunrise Systems is continuously working on producing a thoroughly revised front end for all modules, due for release in the coming months. Dedicated effort has been put into the variable time step algorithm towards modelling the fast component dynamics as well as the model refining.

Included in this issue are the regular features together with a description of the forthcoming releases of the Transient and Standard Modules, the issue of PIPENET™ and Windows XP, patches to all modules as well as the launch of our new web page etc. We hope you find it interesting and informative.

In this issue:

- PIPENET™ Modules and Windows XP
- Patches and Forthcoming Releases of Standard Module 3.23 and Transient 5.14
- An Introduction to Specifications
- Case Studies
- An Obituary for Steve Horn
- Frequently Asked Questions

PIPENET™ Modules and Windows XP

Current PIPENET™ modules are only certified to run on Windows 95, 98, ME, NT (Service Pack 4), and 2000. However, all PIPENET™ modules will run on the Windows XP operating system providing the latest security key drivers are installed. These key drivers are included in the latest releases of Standard 3.23, Spray/Sprinkler 3.23 and Transient 5.14. Users of earlier releases can update their key driver as follows:

1. Ensure that you have Administrator access rights on your computer, since installation of the key drivers requires access to the System Registry;
2. Visit the Sunrise website www.sunrise-sys.com and select Updates. When prompted for a user name and password enter (both in lower case):

   User name pipenet
   Password: pembroke

3. The update is downloaded as a single self-extracting Zip file. Download the file to a suitable location on your hard disk and then double-click on the file to extract the setup files to a suitable directory on your hard disk. Locate the directory using Windows' Explorer and double-click on the file SETUP.EXE to

install the new key drivers.

4. If you subsequently need to re-install an earlier version of a PIPENET™ module, be sure to repeat this procedure, since installing an earlier version of a PIPENET™ module will replace the new key drivers with older versions.

Patches and Forthcoming Releases

Patches to PIPENET™ Modules

Periodically Sunrise will issue releases of the latest versions of all of its modules. These releases are issued on CD-ROM, and are issued to existing customers with MUS agreements, and also to new customers. The latest CD-ROM release was for versions 3.20 of the Standard and Spray/Sprinkler modules and 5.11 of the Transient module. The next CD-ROM release, due shortly, will be for versions 3.23 of the Standard and Spray/Sprinkler modules and 5.14 of Transient.

In between releases, patches that fix minor errors and omissions are made available via our website. Patch releases are available to all customers, and each patch generates a new patch release version. Thus for example, following the release of Standard 3.20, two patch releases were made available on our website 3.21 and 3.22. Note that patches to upgrade to versions (as provided on CD-ROM) are not provided. Thus, for example, a customer wishing to upgrade from version 3.22 of Standard to version 3.23 must have, or purchased, a MUS agreement.

The procedure for obtaining patches is as follows:

1. Visit the Sunrise website www.sunrise-sys.com and select the Updates button. When prompted for a user name and password enter (both in lower case):

User name	pipenet
Password:	pembroke

2. Locate the latest patch for the PIPENET™ module you wish to update and download the appropriate file. The details for each patch include the version of the module to which the patch applies, and details of any significant changes introduced by the patch.

3. Install the patch by following the instructions provided on the Updates page. Generally, this involves little more than placing the downloaded executable file in a specified PIPENET™ directory and then executing the file, usually by double-clicking on the file in Windows Explorer.

Standard and Spray/Sprinkler Modules – Version 3.23

The latest versions of the Standard and Spray/Sprinkler modules will shortly be made available. These releases incorporate all the changes made in the patch releases 3.21 and 3.22 together with a number of other minor corrections. New features include:

- A hydraulic grade line table being displayed in the output file
- Improvements made to the control valve model in the Standard module to make it applicable to a wider range of applications.
- New security key drivers that provide support for Windows XP and Windows ME.

Transient Module – Version 5.14

A new version of the Transient module will also be made available. This release incorporates all of the changes made in patch releases 5.12 and 5.13, together with a number of other minor corrections. New features include:

- The default valve type is now Cv instead of K-factor for all valve types
- New security key drivers that provide support for Windows XP and Windows ME.

An Introduction to Specifications

This article provides a brief introduction to specifications and hightlights some of the problems that new users may encounter. The article is mainly concerned with the Standard Module. Please refer to the User Manual for further details and special considerations which apply to the design phase, nozzles and remote specifications in Spray/Sprinkler.

In order to solve a network, boundary conditions must be provided in the form of flow or pressure specifications on the input and output nodes to the hydraulic system, or pressure specifications on internal nodes (an internal node is any node which is not an input or output node to the system). These specifications must obey the rules described more formally in the PIPENET™ User Manuals and on the online Help. Many aspects of specifications can, however, be described with reference to a simple, single pipe network.

In this simple example, an initial approach might be to provide equal flow specifications on both the input and output nodes. However, since the output flow must equal the input flow, one of these specifications is not required. If we provide two identical flow specifications then there is redundancy, and there is no unique solution to the network. If instead, we provide two different flow specifications then the specifications would be inconsistent, and again there would be no solution.

With one flow specification provided at one node, we know the flow at the other node. However, we do not know the pressure. In fact pressures cannot be determined without the specification of a reference pressure. So, for our simple network, it means that we must provide two specifications, one of which must be a pressure specification. These two specifications may be placed on the same node, or one on each of the two nodes.

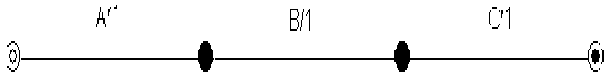
This can be generalised to larger networks with any number of input and output nodes to the simple statement that:

> The number of specifications must be equal to the total number of input and output nodes, and at least one of the specifications must be a pressure

Disjoint Networks

A network is considered disjoint if it is in two or more unconnected parts, or sub-networks. The following is an example of a simple disjoint network, with two sub-networks A and B:

Since each sub-network is solved separately, the specifications in each sub-network must be valid. Thus in the above example there must be a total of four specifications, with sub-networks A and B, each having at least one pressure specification.
It is clear from this example that the network is disjoint. However, disjoint networks can also arise in a less obvious way from the use of breaks and blocks. Consider the following simple three-pipe network, where the central pipe B/1 is blocked, a flow specification on the input to pipe A/1, and a pressure specification on the output of pipe C/1 are provided:



This network was initially setup with the pipe in the normal, unblocked state and the calculation ran satisfactorily with a flow specification provided at the input and a pressure specification provide at the output. When the central pipe was blocked the network refused to calculate - why? Simply, that the blocked pipe has split the network into two disjoint networks, one consisting of the single pipe A/1 and the other of the single

pipe C/1. Whilst the network containing the pipe C/1 includes the original pressure specification, the A/1 network does not have a pressure specification.
It should be noted that with breaks and blocks, specifications are added as follows:

Block

Each of the input and output nodes of the break is assumed to have an associated zero flow specification.

Break

Each of the input and output nodes of the break is assumed to have an associated pressure specification

Hence the addition of blocks and breaks always adds two specifications. In the case of a block, where both are flow specifications, one side of the block may be left without a pressure specification.
Control valves, in the completely closed state, act like blocks and therefore it may be necessary to ensure that pressure specifications are available on both sides of a valve.

Case Studies

THE USE OF PIPENET IN MODELLING PRESSURE SURGES AND LEAKS IN SUBSEA AND ONSHORE PIPELINES

Eur. Ing. Dr. Waheed Al-Rafai, ZADCO, United Arab Emirates

In this paper we present results based on the pioneering work done by ZADCO in pipeline integrity risk management. We believe that this represents a major step achieved by ZADCO in developing techniques for optimising pipeline inspection & maintenance and sets a new worldwide standard. The project is concerned with the integrity modelling of the arterial oil pipeline, a major asset of ZADCO.

ZADCO plan to derive greater value from its pipeline network which is one of its biggest assets covering hundreds of kilometres in the Arabian Gulf. The challenge is to achieve a high level of pipeline integrity, through risk-based approaches which have been gaining attention as a basis for making decisions on inspection and integrity maintenance. Considerable cost savings can be realised when utilising Risk Based Inspection (RBI). For example, RBI techniques generally yield longer inspection intervals compared to time-based inspections, and are effective in prioritising inspections and can also provide the confidence to safely postpone subsea rehabilitation activities.

For example, the water content of ZADCO main oil line is expected to increase in the future. This brings with it the risk of significantly increased pressure surges due to increased water cut, even though the valve closure time may remain constant. The use of state-of-the-art techniques developed by ZADCO is invaluable in optimising and planning costly subsea rehabilitation activities, and in quantifying and justifying the benefit of installing a leak detection system in support of improved pipeline operation.

The total bill for deferred production and repair caused by subsea pipeline failure can be measured in hundreds of millions of dollars. Given that the cost of pipeline failure is of such magnitude, then the use of dynamic modelling should be advocated as an enabling technique for achieving requisite performance. This paper gives an introduction to the role played by PIPENET™ software in this application to enable better pipeline integrity and risk management.

SUBSEA PIPELINE MODELLING

A pipeline Maximum Allowable Operating Pressure (MAOP) may need to be modified from the original design pressure in some cases. If it is raised above the original design pressure, it will have significant implications on the pipeline integrity and risk, which must be evaluated. When an operator increases the pressure, the risk of failure will also increase. Likewise, if it needs to be lowered, this would also have a favourable impact on the risk of failure and the corresponding inspection frequency when utilising Risk Based Inspection.

PIPENET™ provides the means to quantify the MAOP requirement for lines that are placed in a service for which they were not originally designed. Pressure, flowrates, velocities, and the composition of the fluid transported change over time from the initial design, whilst corrosion and erosion reduce the pressure containment ability of a pipeline.

PIPENET™ also allows the investigation and limits the consequences of an accident through designing an appropriate early warning system. Dynamic modelling of pipelines prevent an extreme scenario of risk to an operator who may be steadily increasing the pressure in the pipeline without introducing any mitigation measures.

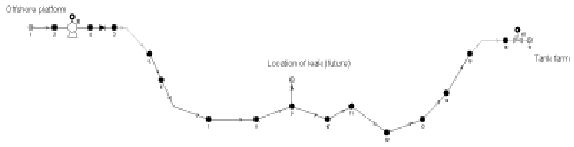
In this example, we consider modelling a pipeline which carries oil from an offshore platform to onshore reception facilities.

- The effect of valve closure and closure time
- The effect of a pipe rupture

The objective in the first case is to determine the relationship between the valve closure time and the maximum pressure with the view of determining the optimum valve closure time. This calculation is particularly important where the integrity demand on the pipeline progressively increases due to weakening by corrosion, the need to transfer greater quantities of oil and an increase in the amount of produced water. By selecting an optimum valve closure time, which is inevitably a compromise between the emergency shutdown requirement and pipeline integrity constraints due to corrosion, the inspection frequency as calculated by Risk Based Inspection and the time to repair the line can also be optimised. The inspection date for the pipeline is a function of the remnant life of the pipeline, which is calculated as the date when the transient pressure containment ability (Maximum Allowable Surge Pressure) of the pipeline equals the maximum pressure surge in the pipeline.

The objective in the second case is to minimise the environmental effect and the waste caused in the event of a subsea pipeline rupture. This is part of conducting a risk analysis in order to ensure that the risk in acceptable. During a leak every second counts and quick response by a leak detection system is critical for improved safety especially for lines handling H_2S-containing fluids. For the purpose of comparison, it was assumed that it would take 15 minutes to detect a leak manually and a further 1 minute to shutdown the pump. On the other hand, with a leak detection system installed, it would take 4 minutes to detect a leak and a further 1 minute to shutdown the pump. The estimated amount of oil which is drained into the sea is an important consideration for contingency planning and the development of an effective Emergency Pipeline Repair System (EPRS).

For the valve closure surge analysis, the network in schematic form is shown below.

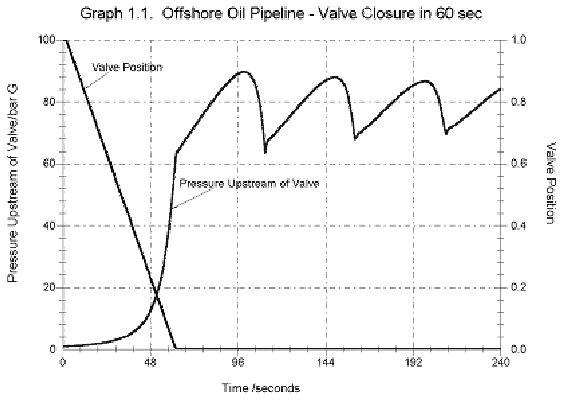


The pipeline is approximately 35 km of 200 mm pipe following the profile of the seabed. The lowest point of the pipeline is 80 m below the level of the platform. Oil is pumped by a booster/ transfer pump and there is an isolation valve at the end of the pipeline.

Consider the following four valve closure cases:

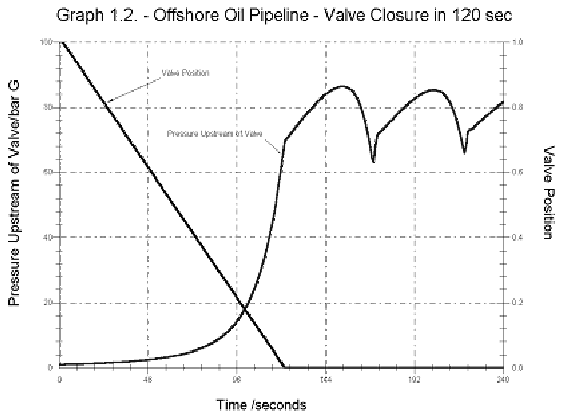
60 sec
120 sec
240 sec
600 sec (quadratic valve closure)

In the first scenario, the valve is set to close in 60 sec. The wave speed is 1159 m/sec. The period for the pressure wave to return to the valve after traversing the length of the pipe is 60.4 sec. As this time, which is sometimes referred to as the critical time, is longer than the valve closure time, this scenario is likely to generate the maximum surge pressure.

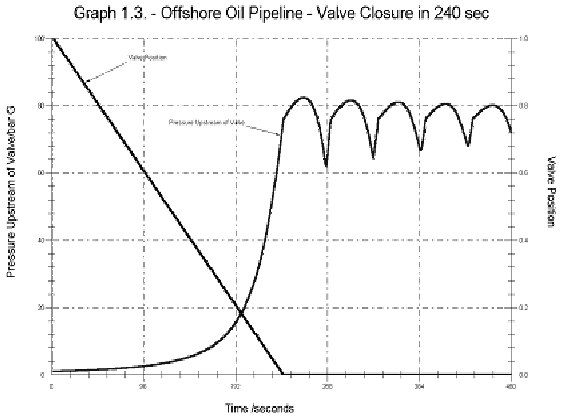


As expected the maximum pressure occurs at the lowest point in the system and reaches a value of 95.3 bar.

In the second scenario, the valve closure time is increased to 120 sec. One would expect the pressure surge to decrease a little but not very significantly. This is because in a system of this type, the pressure surge can be expected to decrease significantly only after the valve closure time is several times the critical time. As described in the previous paragraph, the critical time is the time taken for the pressure wave emanating from the valve to travel the length of the system and return.


Graph 1.2. - Offshore Oil Pipeline - Valve Closure in 120 sec
Valve Position
Pressure Upstream of Valve
Pressure Upstream of Valve/bar G
Valve Position
Time /seconds

The maximum pressure again occurs at the lowest point in the system and reaches 92.5 bar. As expected, this is a little less than the maximum pressure with 60 sec valve closure time but not greatly.

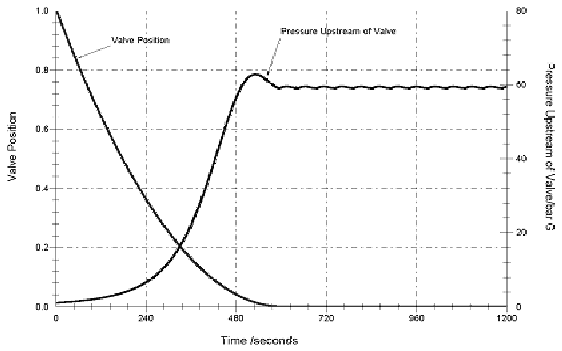


The pressure peak occurs at the lowest point and has a value of 88.9 bar.

In the next case, we consider a valve closure time of 600 sec with a quadratic pattern. The advantage of quadratic valve closure is the following. Generally, the pressure surge is created during the final stages of valve closure. With quadratic valve closure the valve closes quickly to begin with and slowly during the final moments. So, within a given valve closure time, the effective rate of closure during the critical period is slow.

The maximum pressure at the lowest point of the system is 69.1 bar. It is difficult to reduce this significantly for the following reason. The

Graph 1.4. - Offshore Oil Pipeline - 600 sec Quadratic Valve Closure



closed head of the pump is 57 bar. The additional pressure due to static head is approximately 7 bar. The pressure at the lowest point would therefore be 64 bar even without any pressure surge.

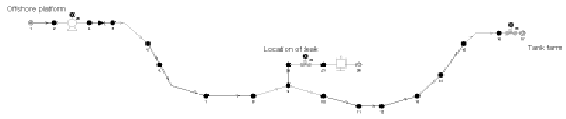
The next scenario we consider is the case in which a subsea pipeline ruptures on the seabed. This is potentially a serious hazard from two points of view. In an area like the Arabian Gulf, leakage of oil into the sea could be a major disaster. Furthermore, the sheer waste is something an operator has to contend with.

One major issue in a matter like this is the analysis of the economics of the system. Is it cost effective to install a leak detection system? It would therefore be of interest to consider two cases.

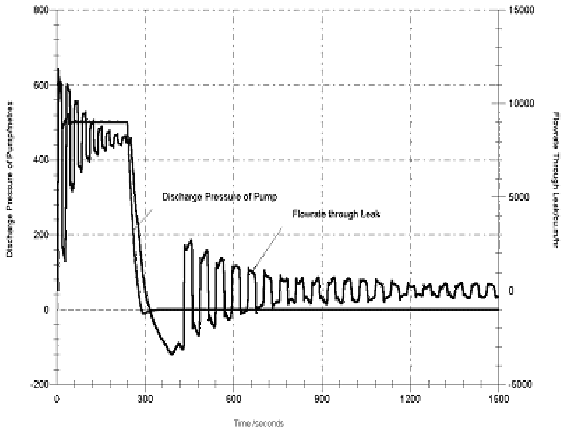
- The case in which a leak detection system has been installed.
- The case in which a leak detection system has not been installed.

In both cases, we assume that the leak takes 30 sec to fully develop. The leak itself occurs approximately 15 km downstream of the pump.

In the first case, the leak is detected 240 sec after it begins and a signal is sent to the pump to stop and the valve to close. After receiving the signal to stop, the pump takes 60 sec to wind down. The valve closes in 180 sec after receiving the signal to close. The system schematic and the graphical results are shown below.

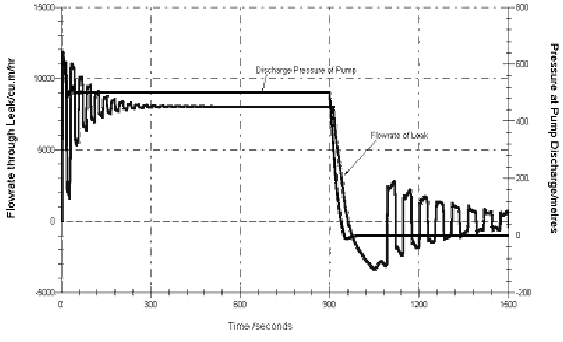


Graph 1.5. - Offshore Oil Pipeline - Pipe Rupture



In the second case, we assume that the pump continues to operate and the valve remains open even after the leak starts. The operators manually detect that there has been a leak and the system is shutdown 15 minutes after the leak starts.

Graph 1.6 - Offshore Oil Pipeline - Pipe Rupture



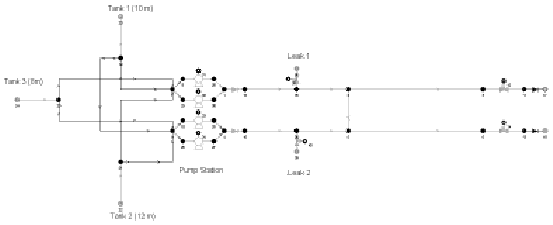
As expected, the case without the installation of the leak detection system has a considerable environmental impact. In addition, PIPENET™ can estimate the amount of oil which has leaked into the sea in the above cases. PIPENET™ can also be used to assess the impact of parameters such as the response time of the leak detection system, the spindown time of the pump,

the valve closure time and other parameters.

Amount of leakage with leak detection system - 600 m^3
Amount of leakage without a leak detection system- 2070 m^3

ONSHORE PIPELINE MODELLING

The second case we consider is an onshore cross-country pipeline system. The system imports oil from three tanks in a tank farm and delivers to two delivery points using two parallel pipelines. The oil is pumped by one pumping station consisting of four pumps, connected in the form of two parallel sets. The parallel pipes have an interconnecting pipe approximately half way along.



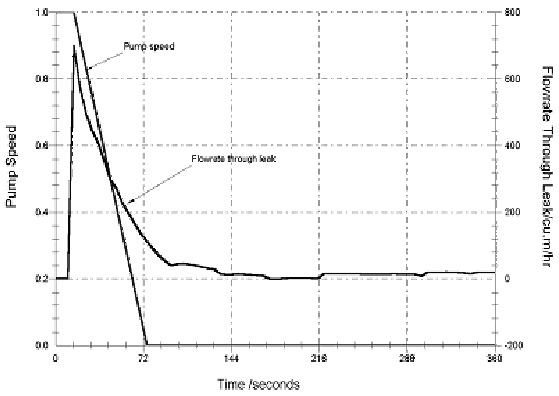
We model the case in which both pipelines rupture approximately in the same location. The leak fully develops in 10 secs. The following scenarios are considered.

- In the first scenario, we assume that a leak detection system has been installed which sends a signal to shut down the pumps, within 5 sec of the leak developing. The pumps themselves take 60 sec to spin down. (Graph 2.1.)

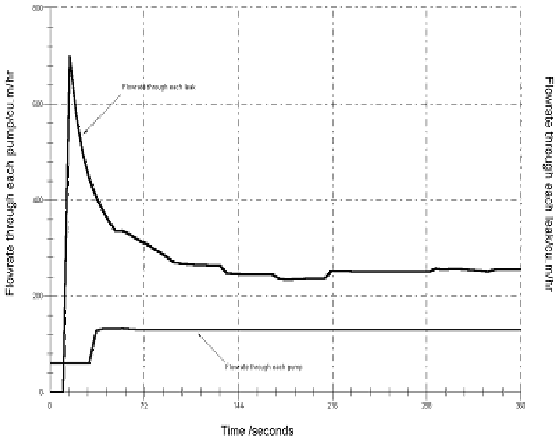
- In the second scenario, we consider the case where a leak detection system has not been installed. The pumps continue to operate normally even after the leak occurs. (Graph 2.2.)

In both the scenarios, there is a rush of oil when the leak occurs. However, in the case where a leak detection system has been installed, the flow rapidly goes down to almost zero. There is

Graph 2.1 - Onshore Oil Pipeline - Pipe Rupture



Graph 2.2. - Onshore Oil Pipeline - Pipe Rupture



a small remaining flowrate because of the static head caused by the oil level in the tanks. In the scenario without the leak detection system, the flowrate through the leak continues at a substantially higher level.

PIPENET™ can be used to estimate important factors such as the volume of leakage and the impact of parameters which are under the control of the pipeline integrity engineer.

CONCLUSION

ZADCO has achieved pioneering leadership in the field of developing pipeline integrity risk management techniques. In this paper, we have shown how to achieve practical benefits by illustrating the application of this technology in

support of pipeline integrity risk management initiatives. This is an important issue in the Arabian Gulf.

The dynamic nature of pipeline operations makes the risk picture a complex one. Many lines are placed in a service for which they were not originally designed. Pressure, flowrates, velocities, and the composition of the fluid transported change over time from the initial design. Inspection, maintenance and repair are weather dependent as well and require boats, special equipment and expensive personnel, adding to the costs.

Dynamic modelling using PIPENET™ can allow more informed decisions to be made in order to better manage pipeline assets including reduce wasted efforts in inspection and maintenance. The result of this work is an increase in safety and reliability of operating pipelines at the lowest possible cost.

THE AUTHOR

Dr Waheed Al-Rafai obtained his PhD in Fluid Mechanics in 1990 from LJM University. He worked for Brown & Root Energy Services in the Arabian Gulf, USA and the UK. He now works for ZADCO in the UAE, with responsibility for developing a Pipeline Integrity Risk Management System for an extensive subsea pipeline network. He is a Fellow of the Institution of Mechanical Engineers in London and has a Master of Business Administration degree from Surrey University. He is the author of a number of papers on pipelines and related technologies.

Steve Horn

It was with great sadness, we all learnt that Steve Horn passed away on 31 July 2001. Not only was Steve a PIPENET™ user for over 20 years, he was also a friend and colleague to many of us. He was an inspiration to all of us and some of the key features of PIPENET™ are a result of his suggestions. He will be missed by all of us. Steve is survived by his wife, Lyn and two sons.

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New Web Page

Our new web page was launched in 2001. Visit www.sunrise-sys.com to download the latest program patches, download previous newsletters, view answers to frequently asked questions and much more.

Next Issue

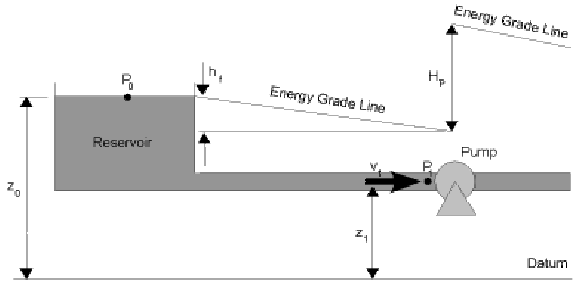
The next issue will include more of the regular sections “Case Studies” and “Frequently Asked Questions”. We will also describe, in more detail, the revised suite of modules which are due for release in the coming months.

We always welcome any contributions to the newsletter from our users. In particular, we would like to receive more case studies such as those we have already featured in this and previous newsletters.

Frequently Asked Questions

Q1: What are NPSH and Cavitation Parameter and where can I find out more?

"Mechanics of Fluids" by B. S. Massey (ISBN: 0748740430) is a good general purpose textbook on the principles of fluid mechanics. It provides a discussion on NPSH and the Cavitation Parameter. This discussion is paraphrased here.



Consider a reservoir supplying a pump as shown in the figure. Applying the energy equation between the surface of liquid in the supply reservoir and the entry to the impeller, we have:

$$P_0/\rho\, g + z_0 - h_f = P_1/\rho g + v_1^2/2g + z_1 \quad (1)$$

where: v_1 and P_1 represent the fluid velocity and static presure, respectively, at the inlet of the pump; z_1 represents the elevation of this point above datum; z_0 represents the elevation, above datum, of the surface of the reservoir; and P_0 represents the pressure at the surface of the reservoir.

Now, $v_1^2/2g$ may be taken as a particular proportion of the head developed by the pump, say $\sigma_c H_p$. Then we have:

$$\sigma_c = (P_0/\rho g - P_1/\rho g + z_0 - z_1 - h_f)/H_p$$

or

$$\sigma_c = (P_0/\rho g - P_1/\rho g + \Delta z - h_f)/H_p$$

where $\Delta z = z_0 - z_1$

For the prevention of cavitation at the inlet of the pump, P_1 must be greater than P_v, the vapour pressure of the liquid, i.e. $\sigma > \sigma_c$ where:

$$\sigma = (P_0/\rho g - P_v/\rho g + \Delta z - h_f)/H_p \quad (2)$$

and σ_c is the critical value of this parameter at which appreciable cavitation begins.

The numerator of the expression (2) is the Net Positive Suction Head (NPSH).

In PIPENET™, the supply reservoir may be considered the input node of the pump. In this case Dz and h_f become negligible, and the NPSH becomes:

$$NPSH = P_0/\rho g - P_v/\rho g$$

and the cavitation parameter:

$$\sigma = (P_0/\rho g - P_v/\rho g)/H_p$$

In summary, the NPSH may be considered to be a safety factor indicating the "spare" head available to the pump above the head at which would cause cavitation. The cavitation parameter is an expression of the same, but as a proportion the pump head.

Q2: In the Transient Module, why do I need to enter a Suter Curve for a Turbo pump?

During a transient simulation, changing the operating condition of a pump may result in unsteady flow in a hydraulic system. This may be during normal start-up, normal shutdown, or sudden loss of power to the pump. Immediately after a pump start-up, the hydraulic system mostly experiences a local pressure rise, and immediately after a shutdown and power loss there is depressurisation. If pressures fall below vapour pressure, they may cause a growth and subsequently collapse of vapour cavities leading to a transient event. In the Transient Module, there are two types of pumps that may be used to simulate such a pump: a Simple Pump or a Turbo Pump. In circumstances where it is important to analyse unsteady flow caused by a pump, it is important to simulate the pump by a Turbo pump.

When such analysis is not as crucial, a Simple Pump is sufficient for the simulation and in most cases is perfectly adequate.

During a transient, a pump may experience a reversal in flow through the pump, or a change in its rotational speed, or both. Furthermore, it may also experience negative torque values and/or pressures during a transient event. Hence for accurate simulation of a Turbo pump, more performance data are needed and should cover regions of abnormal operation. Any unusual behaviour exhibited by the pump, even momentarily, may influence a transient event. These data may be presented graphically in the pump's corresponding Suter Curves. The curves express the head-flowrate, W_H and torque-flowrate, W_B for the turbo pump for all regions of operation, where the flow conditions (i.e. head, flowrate, speed and torque) are non-dimensional and expressed as percentages of the rated values: values at the point of best efficiency. A detailed description of the Suter transforms may be found in the Transient Module Technical Manual, Chapter 1, page 18.

The figure shows typical Suter curves for a Radial Pump. The regions referred to in the figure are termed as Zones and Quadrants[1]. Each quadrant is of length $\pi/2$ and the zones lying therein are split at zero head-flowrate and torque-flowrate values. There are eight possible zones of pump operation: four occur during normal operation and four are abnormal zones. During a transient event, a pump may enter most, if not all, regions in the figure depending on the appropriate circumstances.

Normal Quadrant $\pi - 3\pi/2$ Zone D represents the region of normal operation of a pump. All four quantities: head, H; flowrate, Q; pump speed, N; and, applied torque, T, are defined as positive. The head is defined to be the difference between the outlet and inlet values. The flowrate is defined to be positive if the fluid passes from the inlet to outlet. The pump rotational speed is defined positive in the clockwise direction as depicted and the applied torque is the difference between the motor torque applied by the pump and the fluid torque imparted on it. In this case, the flowrate is positive indicating useful application of energy. A machine can operate in Zone E if it is being overpowered by an upstream pump or reservoir or there is a sudden pressure drop during a transient event such as a pump trip. When in Zone F, it is likely but not useful that a pump may generate power with positive flow and pump speed due to the negative head and result in positive efficiency given the negative torque. The efficiency is low due to either poor entrance and/or exit flow conditions.

Dissipation Quadrant $\pi/2 - \pi$ The pump usually enters Zone C shortly after a pump trip. Even if there is a downstream operating valve, the combined inertia of the motor and pump and its entrained fluid, may maintain a positive pump rotation but at a reduced value at the time of flow reversal due to the positive head on the machine. This may be momentary depending on the rate at which the downstream operating valve is closed. This zone is purely dissipative and results in negative or no efficiency.

Turbine Quadrant $0 - \pi/2$ After completing Zone C, the pump may experience flow conditions of Zone B depending on the presence of a downstream operating valve. In this zone, the pump rotational speed is now negative forcing the pump to 'run away' and the applied torque is positive. Even though the 'run away' pump is not generating any power, it is precisely the same zone of operation of a hydraulic turbine with positive values of head and torque but negative values for pump speed and flowrate. Zone A is encountered subsequent to a pump trip or a machine that has failed earlier. The difference between Zones A and B is that the sign of torque has changed, and hence the pump experiences a braking effect. This reduces the free wheeling nature of the pump. In fact, the actual 'run away' condition of a pump is attained at the boundary of the two zones when there is no applied torque.

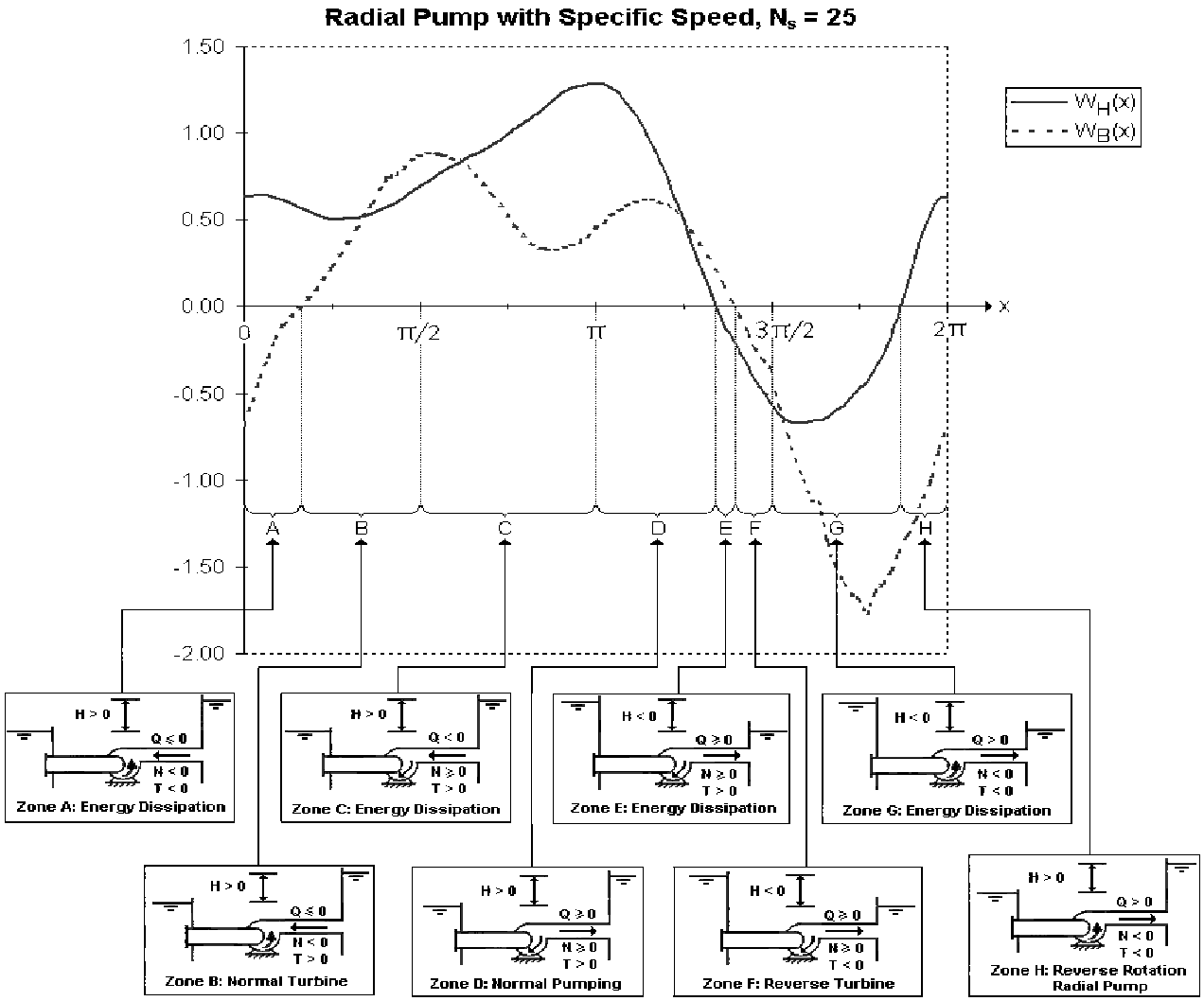
Reversed Speed Dissipation Quadrant $3\pi/2 - 2\pi$ Zones G and H are very unusual and infrequently encountered in operation. Pumps that are designed to increase flow from a higher to lower reservoir, and are inadvertently rotated the wrong way may encounter these zones. Zone G is a purely dissipative zone. Zone H is the only zone to have different flow conditions depending on the type of pump used. A radial pump will

produce positive flow with a considerable reduction in capacity and efficiency compared to normal pumping giving a positive head across the machine. Mixed and axial pumps create flow in the opposite direction and a head increase in the direction of flow.

As it is not always possible to obtain the complete Suter Curve from the manufacturer, one may model the pump as a typical, built-in radial flow, mixed flow or axial flow pump, depending on the pump Specific Speed, $N_S=N_R\ Q_R^{1/2}\ H_R^{-3/4}$, where $_R$ indicates rated values. It is possible to do so as pump's Suter curves tend to have similar shapes, for the same Specific Speed. Alternatively, the curve may be estimated by interpolation with the PIPENET™ built-in curves.

If one would like to enter a user-defined Suter curve, one must first non-dimensionalise the physical quantities and apply the Suter Transforms. The abscissa, x ranges from 0 to 2π. If the flowrate is negative AND the pump speed is strictly negative, then x ranges between 0 and π/2; if the flowrate is strictly negative AND the pump speed is positive, then x ranges between π/2 and π; if the flowrate is positive AND the pump speed is positive, then x ranges between π and 3π/2; and if, the flowrate is strictly positive AND the pump speed is strictly negative; then x ranges between 3π/2 and 2π.

[1] *Martin, C. S., "Representation of Pump Characteristics for Transient Analysis", ASME Symposium on Performance Characteristics of Hydraulic Turbines and Pumps, Winter Annual Meeting, Boston, November 13-18, 1983, pp. 1-13*



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PIPENET™ NEWS

Leading the way in fluid flow analysis.

Volume 1 - Issue 4 October 2000

Editorial

Sunrise Systems is currently focusing its efforts on producing a thoroughly revised suite of all modules, Standard, Spray and Transient, due for release in 2001. See “Developments in Progress” for a brief overview.

This issue of the newsletter also includes the regular features together with a description of the latest revision to the Transient Module, Version 5.10. We hope you find it interesting and informative.

In this issue:

- New PIPENET™ Releases
- Transient Module Two - Node Caisson
- Upgrade Patches
- Email Address
- Developments in Progress
- Shows and Events
- Case Studies
- Frequently Asked Questions
- Next Issue

New PIPENET™ Releases

The current version of the PIPENET Transient Module is 5.10. The new features and improvements in this release are described below.

Transient Module Version 5.10

A major new feature of Version 5.10 is the provision of a Two-Node Caisson component. This component models the behaviour of a caisson or partially filled pipe, both charging and discharging. The Two-Node Caisson is described later in this newsletter. Other new features are summarised below.

- The user is prompted to save all unsaved files before performing a calculation.
- Default filenames are provided for all the output files if the *.dat file has been saved before performing a calculation. This facility does not over-ride any user choices.
- A graph data file (*.res) is now generated by default whenever output graphs are selected. The default output timestep for the graph data file (*.res) has been made application dependent.
- PID Controllers and Transfer Functions are now automatically set to the correct type, depending on the component that they are connected to. When adding a Specification

to an Info Node, the default type is now "Information". This only applies if the components are added using the schematic display.

- When printing the schematic display the print dialog now includes the option to print to fit a page.

- A facility has been added to the options' toolbar to provide a default tag to be used for the creation of new components.

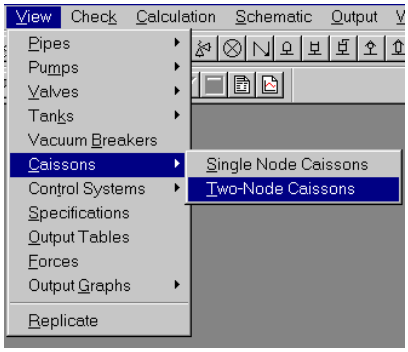
- The Area Tool will now move both nodes and waypoints, and will retain the snap-to-grid option. Nodes and waypoints that were on a grid point prior to the move will still be on a grid point after the move.

- Most component related limits have been increased. The new set is listed below.

Component	Old Limit	New Limit
pipes	300	1000
short pipes	300	1000
single compressible flow pipes	1	1
valves	40	100
specifications	100	200
pumps	40	100
turbo pumps	40	100
pump failures	40	100
non-return valves	40	100
check valves	40	100
fluid damped check valves	40	100
liquid surge relief valves	40	100
regulator valves	40	100
inertial check valves	40	100
caissons	40	100
accumulators	40	100
surge tanks	40	100
simple tanks	40	100
vacuum breaker valves	40	100
sensors	40	100
pid controllers	40	100
transfer functions	40	100
fittings	100	100
output tables	100	100
tags	60	250
special equipment items	100	100
tabulated curves	80	200
points in the curve buffer	8000	20000
regions of interest	40	100
parameter against x graphs	20	50
snapshots	20	50
total number of components	1380	4000
nodes in network	2760	8000
forces in network	2760	8000

Transient Module Two - Node Caisson

The new Two-Node Caisson has been developed in response to customer demand. It can be used alongside the existing (One-Node) Caisson but is more versatile and easier to use. It can be used just like a pipe, and it acts as one when it is full. This makes it ideally suited to investigate pressure surges arising in situations such as pump priming.



The Two-Node Caisson models a partially filled pipe. The caisson is filled with liquid from the input node up to the fluid level and contains air from the fluid level up to the output node. This implies that the caisson's elevation should be positive, otherwise the simulation cannot continue.

The fluid level in the Two-Node Caisson can rise or fall during a simulation as long as it does not empty. The simulation continues normally when the Two-Node Caisson fills completely; it then acts as a Short Pipe. However, the simulation will be stopped if it drains completely, since this would lead to draining of adjacent components. This should be borne in mind when starting with an initial fluid level close to zero. In

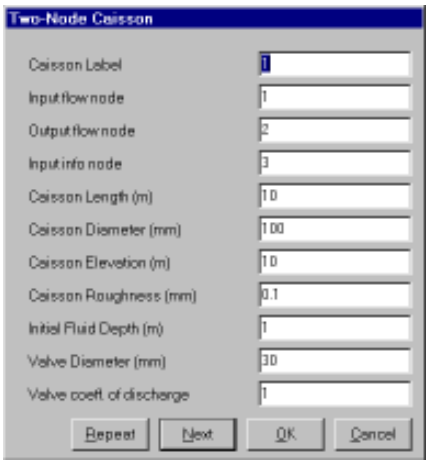
this case some small fluctuations can potentially stop the simulation.

The Two-Node Caisson has a number of built-in features to enable realistic simulation of a partially filled pipe. These are discussed below.

A built-in air inlet/outlet valve (positioned at the output node) controls the flow of air in and out of the caisson while it is partially filled. This air valve is considered fully closed when the Two-Node Caisson is full.

A Non-Return Valve is also built-in at the output node of the caisson to stop it filling up from this side. Note that because of this the Two-Node Caisson starts draining as soon as the flow at the outlet subsides, i.e. flow cannot enter the Two-Node Caisson through its output node. The implication of this is that a Two-Node Caisson can only be filled from its input node. The caisson's elevation should always be positive.

In addition to the usual parameters such as input and output nodes, the Two-Node Caisson has the parameters shown below.



- Input info node

An information specification at this node sets the air valve (0=closed, 1=fully open).

- Caisson diameter

This is the internal diameter of the caisson.

- Caisson elevation

This is the relative change of elevation, i.e. level of the output node minus level of the input node. Note that the elevation of the caisson should be positive.

- Caisson roughness

This is used for the computation of the friction factor.

- Initial fluid depth

This is the level of the liquid in the caisson at the start of the simulation as measured along the length of the caisson. Note that the caisson might start with a fluid level that is different from this setting if "Initial Steady State" is selected.

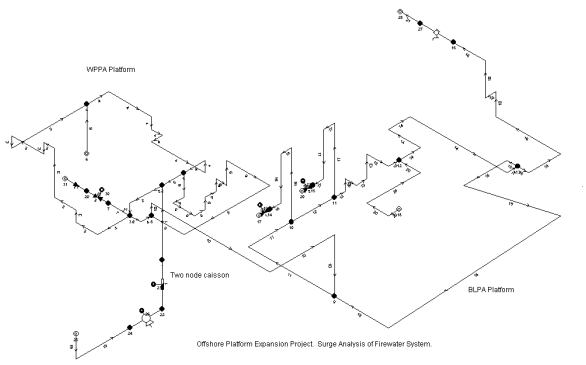
- Valve diameter

This is the diameter of the air valve. The air valve model used in the caisson is identical to the one used in the Vacuum Breaker.

- Valve coefficient of discharge

This is used to account for the fact that the effective cross-section of the valve is normally less than the actual cross-section, and there are frictional losses. In the absence of manufacturer's data a coefficient of 0.9 can be used as a first approximation.

Example: Firewater Ring Main System – Pump Priming


WPPA Platform
Two node caisson
BLPA Platform
Offshore Platform Expansion Project. Surge Analysis of Firewater System.

Fire pump priming is known to be a potential cause of unacceptable levels of pressure surge

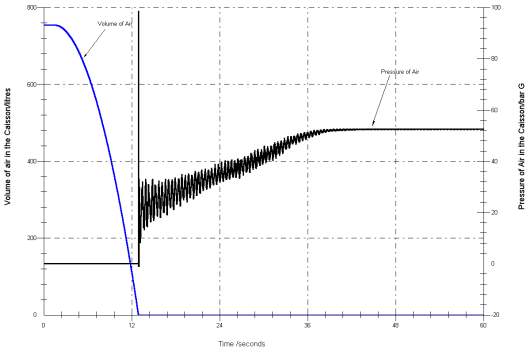
in fire water systems. Fire pumps are typically started under two circumstances.

- If there is a fire and, as a result, the firewater ringmain depressurises.
- During routine tests of the firewater pumps, which are generally carried out once a week.

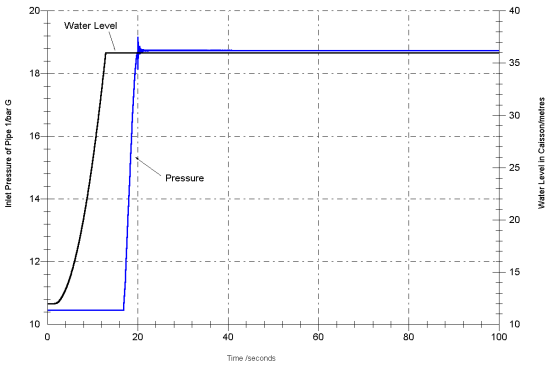
Under both these circumstances, water which rises rapidly in the dry riser pipe could be brought to rest instantaneously on completion of priming. This is likely to cause a substantial pressure surge, unless an escape route is found by the water. This is typically provided by an overboard dump valve, which is closed after priming in a manner which will reduce the level of pressure surge to an acceptable value.

The graphs, which have been produced by PIPENET Transient module, show the remarkable difference between priming with and without an overboard dump valve. The installation of an overboard dump valve of an appropriate size almost completely eliminates the pressure surge.

Graph 1.4. - Pump Priming with No Overboard Dump Valve



Graph 5.1. - Pump Priming with Overboard Dump Valve(Cv=3000, 15-20 sec Closure)



Upgrade Patches

Minor upgrades to PIPENET modules are now available for download at the Sunrise Systems' web page at www.sunrise-sys.com. In order to access the 'Upgrades' page, users will require a user name and password. Users may request a user name and password by emailing support@sunrise-sys.com.

Each patch is applicable to one and only one PIPENET module. Each patch will only work with a specified version of a module, and can only be applied once. Checks will be made to prevent users from applying the patch twice, or attempting to apply the patch to the wrong file. The name of each patch file has a regular form consisting of a three character designation for the module being updated Std (Standard), Spr (Spray/Sprinkler) and Trn (Transient), followed by the version being updated, then followed by the new version number. For example, the patch to upgrade Version 3.20 of the Standard Module to Version 3.21 is:

Std_V320_V321.exe

To install a patch, first download the file to your hard disk. It is recommended that the file be placed in the "Exec" sub-directory of the installation directory for the version of the module that is being updated. Double-click on the file (or choose Run from the Start menu) to install the patch.

Alternatively, the patch file may be downloaded to any directory on your hard disk and the patch applied by the command (or choosing Run from the Start menu):

<patchfile><installation_path>\exec

where <patchfile> is the name of the patch and <installation_path> is the directory where the module was originally installed. For example, if the patch from Version 3.20 to Version 3.21 is to be applied to the Standard Module in the default installation directory, then the command would be:

Std_V320_V321 C:\PIPENET\std3.20\exec

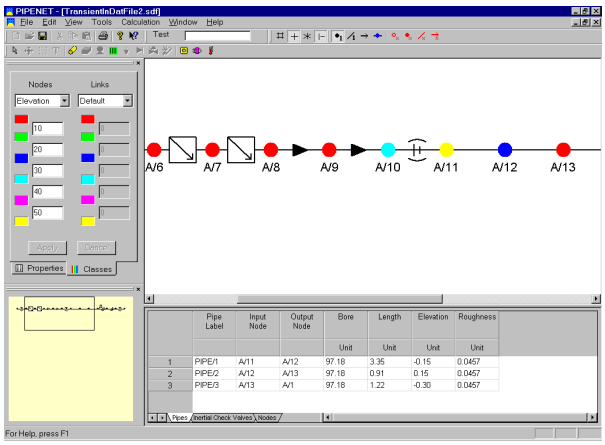
Major releases are not available by patched downloads. These will continue to be distributed on CD-ROM by post.

Email Address

Please note that our correct email address is pipenet@sunrise-sys.com. Customers who have not contacted Sunrise Systems recently should be aware that the old email address: pipenet@sunrise.ndirect.co.uk has been terminated and is no langer valid.

New PIPENET User Interface Development

The following is a screen capture of the new graphical user-interface development, illustrating some of the radical and exciting new developments taking place. There is still much work left to complete this development and the appearance may change.



The four main areas depicted are as follows:

- Upper-left: a tabbed window used for displaying the attributes of the currently selected component, a colour scheme, user notes, status, etc. Here we show the colour scheme window, via which the user can select which attributes are displayed on the schematic and which colour is to be used for drawing the component. For example, here we are displaying node elevations and pipe bores. Elevations less than 10 units will be displayed in red, elevations between 10 and 20 units in blue, and so on.

- Lower-left: overview window showing an overall view of the schematic, with a rectangle showing the region covered by the main schematic. The rectangle may be dragged, with the main schematic window being scrolled to reflect the changes.

- Upper-right: the schematic window, essentially as in the current system, but allowing colour coding, multiple selections, an improved Area Tool with flip and invert operations, and undo/redo.

- Lower-right: a tabular view of the database, via which the user can display and edit component properties, and display results.

When released the new user interface will support all current modules and will automatically reconfigure itself according to the type of data file opened. For example, if a Transient file is opened the toolbars and menus will reflect the options available for the Transient Module.

Import and export of data will be provided via copy/paste and “plugins”. The former will make it possible to copy/paste between the tabular view and a spreadsheet, and the latter will provide a more flexible import and export mechanism. Using Sunrise Systems’ or user supplied plugins it will be possible to interface to external databases, CAD/drawing packages, etc.

Shows and Events

Sunrise Systems Limited attends shows and exhibitions. This newsletter has been timed to coincide with the presence and demonstration of our full range of PIPENET products at ADIPEC 2000. The show is being held during the period October 15 – 18, 2000 in Abu Dhabi, United Arab Emirates. Sunrise Systems is being represented by ImageGrafix in booth 3509 at the Abu Dhabi International Exhibition Centre.

Case Studies

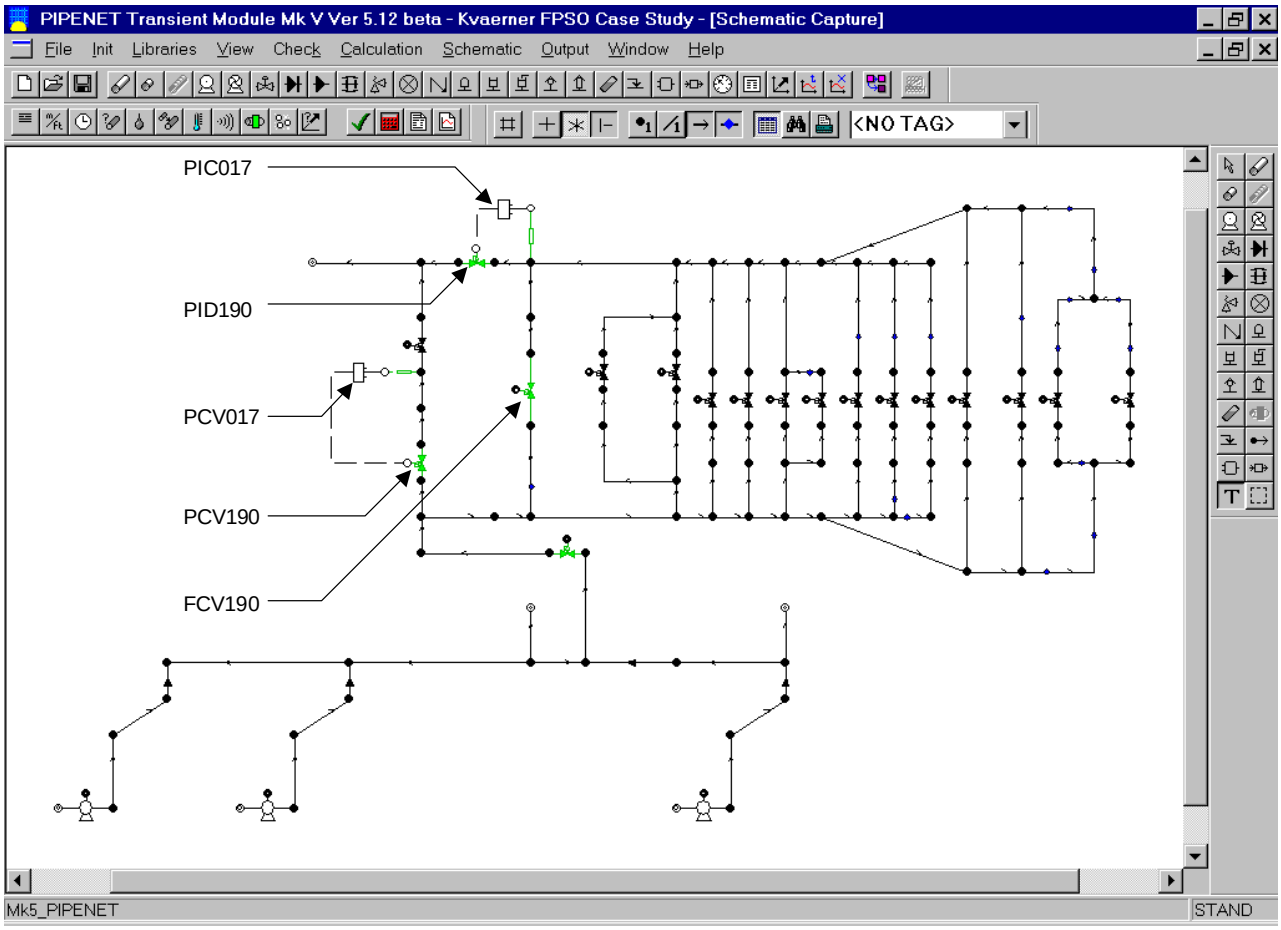
Case Study 1 Surge Analysis of a Floating Platform Storage Offshore Seawater System

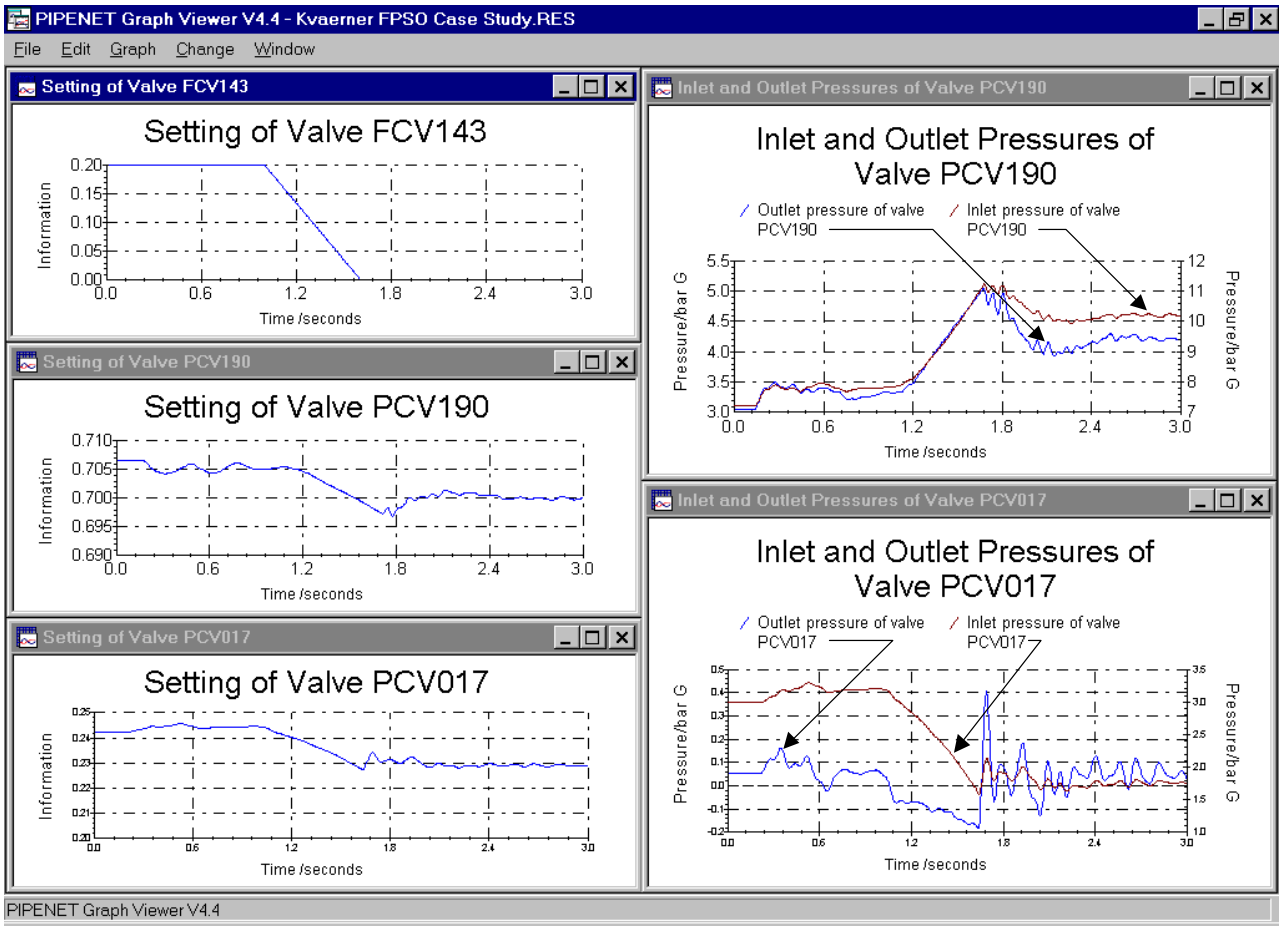
Kvaerner E&C (Australia) was commissioned by a client to investigate operational difficulties that have been experienced on the seawater system of a floating platform storage offshore (FPSO). These difficulties included: water hammer when the system was returned to normal operation after tripping to firewater mode; water hammer when the standby seawater lift pump was started; and water hammer when the minimum flow control valve closed quickly on instrument air failure.

The study utilised Pipenet Transient Module to model the events that caused water hammer and then to investigate methods to mitigate the forces generated.

The major problem identified when the seawater system was returned to normal operation was that the slow tuning required of the seawater return back-pressure controller resulted in the valve remaining open for some time after the SW/FW isolation valve had closed. This allowed the seawater system to drain partially, causing vapour pockets to form at high points. When the system was re-started, these vapour pockets collapsed with the consequence that shock waves were generated. Any air entrained within the system would cause severe slugging as it was brought back online. The modifications comprised a software change to close the back-pressure control valve on trip to firewater mode, and a procedure to utilise the drain valves around the main isolation valve to prime the system before re-opening the main isolation valve.

The changes to the standby seawater lift pump system comprised modifications to the discharge check valves. There were three check valves in the discharge line: one immediately downstream of the pump; and two further along the discharge





line. Due to leakage past the pump discharge check valve it was possible to draw a vacuum between the check valves when the pump was idle. It was therefore proposed to remove one of the latter valves and to drill a small hole into the remaining second check valve. The simulations showed that this ensured that the discharge line would remain primed between standby pump operations.

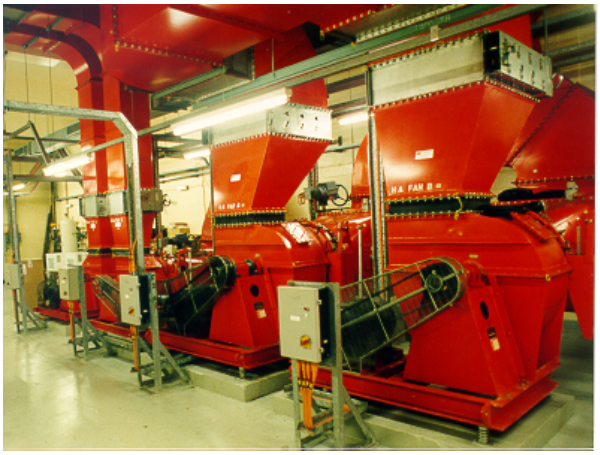
Instrument air failure was simulated to investigate the maximum closure rate for the minimum flow control valve that would not cause waterhammer.

Key findings of the study were:

- the offline seawater system must be fully primed before opening the main isolation valve;
- the standby pump discharge must be fully primed at all times to prevent starting into a dry riser;
- all main control valves must have relatively slow closure times defined by their actuator, so that they cannot cause waterhammer on instrument air failure.

This article was written by Mr A Jamieson and has been reproduced with the kind permission of Kvaerner (E&C) Australia.

Case Study 2 Modelling of Ventilation Systems on a Nuclear Facility



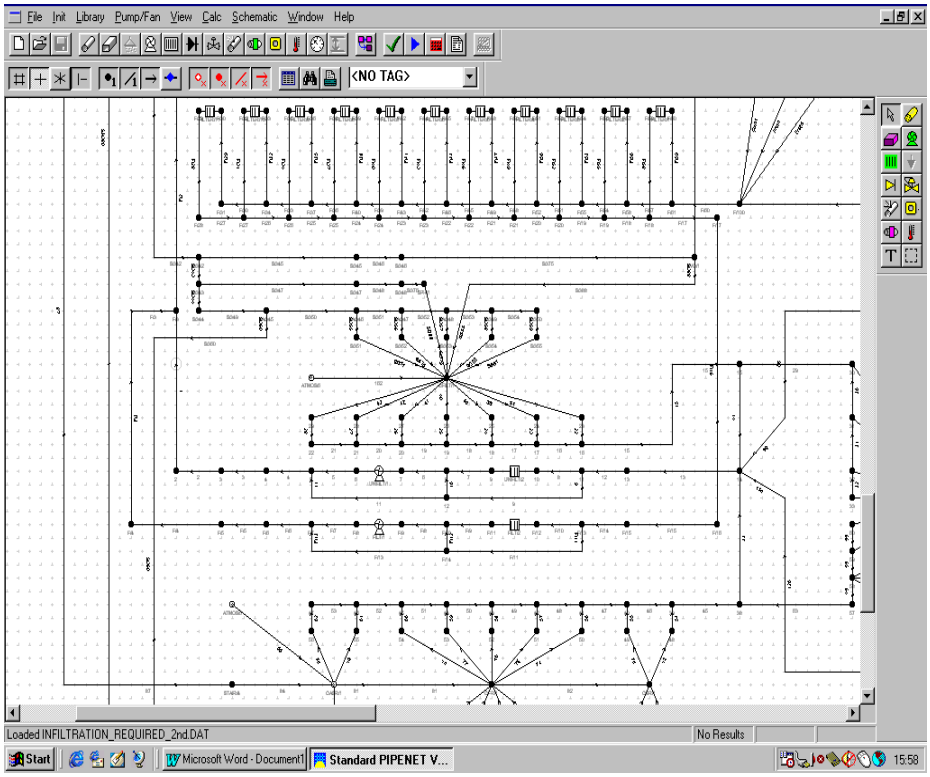
Electrowatt-Ekono in collaboration with AWE Aldermaston have successfully developed ventilation system models for various process plant facilities on the AWE site. The work supports existing plant operations and will assist with design and installation works associated with continued operation and future decommissioning activities on the site.

The models developed are for radio-chemical process facilities in which the ventilation systems provide an important dual role; firstly to control the working environment, in terms of maintaining comfortable working conditions; and secondly to provide an important safety function whereby system containment is ensured.

Within nuclear process plant it is necessary to achieve a predefined air throughput to ensure that acceptable activity levels are maintained throughout the plant. Further, it is required to operate according to a containment philosophy whereby all areas of plant operate at a depression relative to atmosphere. Within the plant a depression gradient is established such that air is cascaded through various defined containment levels, thereby establishing a contamination gradient within the plant. Operating at a depression ensures that any leakage paths occurring in the system will result in an inflow of air to the facility, hence containing any activity present. Ventilation air which has passed through a radio-chemical process plant could potentially pick up activity and cannot be exhausted directly back to atmosphere. There is, therefore, significant filtration clean-up plant associated with the exhaust side of the process. Traditional methods used to analyse ventilation systems involve the use of hand calculations that work through the system components in turn. Although this is a perfectly acceptable method of qualifying or designing a system, it is error prone, tedious, and not particularly flexible in terms of responding to the evolution of a design. Alternatively, as has been demonstrated by the AWE modelling, it is possible to develop whole ventilation system models using the pipe network analysis program PIPENET, which allow parametric design studies to be performed for a variety of plant operating conditions (including normal and fault operation). Plant design or operational changes can readily be incorporated into such a model, and the consequences of these can be investigated with relative ease. Using such methods the design of the plant can be optimised to match the design criteria in a cost-effective manner.

Generally, when designing a ventilation system it will be necessary to ensure that, for normal operation, there is sufficient head provided by the fans to overcome the associated system parasitic losses at the specified design flow rates. Further, it may be necessary to demonstrate how the system behaves during a fault condition when equipment within a ventilation system may have failed. The work at AWE has concentrated on supporting current operations whilst providing an analysis tool which will be invaluable at the planning stage for future decommissioning works. PIPENET predictions will be utilised to support any plant changes to be implemented as an integral part of decommissioning. This could include the removal of whole sections of plant and/or estimating the consequences of reducing air throughput in the plant, etc.

The PIPENET models developed to support this project are large by comparison with other applications; typically having in excess of 1000 components, including a large number of control valves, multiple fans and a significant number of HEPA filtration systems. The systems are extremely dendritic in nature and all end points require linking back to a common ambient



The schematic display of the network comprising:

214 pipes
321 ducts
10 pumps/fans
80 filters
199 control valves

boundary condition.

Supply and extract systems have been simulated along with the infiltration that would be associated with any system running at a depression relative to ambient. The models have all been validated against detailed plant measurements and have become an important component in the baselining of plant operation.

Sensitivity studies have been performed to investigate the consequences of system failures (i.e. fan failures), the effect of filter loading (i.e. increased losses as filters get dirty) and also general flow and pressure distributions within the facility. The model can readily be used to fine tune system performance and increase/ optimise system efficiency.

The project has been carried out as a team effort between AWE and Electrowatt-Ekono whereby a degree of technology transfer has been supplied to enable AWE staff to develop in-house skills thereby ensuring a degree of self-determination to support future requirements.

The PIPENET Standard Module by Sunrise Systems has been utilised for this work and all models developed are to be maintained to represent current plant conditions faithfully. The ventilation models will become a "living" simulation tool into which plant upgrades, operational changes and features associated with plant decommissioning will be incorporated.

This article was written by Mr S V Worth (Electrowatt-Ekono (UK) Ltd) and has been reproduced with the kind permission of Mr S Hingston (AWE).

Electrowatt-Ekono (UK) Ltd is a leading independent engineering consultancy which has been supporting the nuclear industry for many years. Such support includes safety analysis and documentation, waste management appraisals, decommissioning planning, strategy development and review of documentation and proposals. More recently, expertise has been developed in respect of assessment of performance and upgrade requirements for ventilation and containment systems as operational and regulatory requirements change. A key feature of the work carried out by Electrowatt-Ekono is the importance attached to Site Licensing and Safety Justification as designs and proposals are formulated, thereby ensuring that potential difficulties emanating from the necessary approvals procedures are minimised or eliminated.

Electrowatt-Ekono has a full working knowledge of the requirements of AECP 1054, Ventilation of Radioactive Areas and AECP 59, Shielded and Ventilated Glove Boxes, for hands-on operation.

Frequently Asked Questions

Q1. I set the required number of specifications in accordance with the specification rules in the manual. A check on the status of the network suggests that all components are adequately specified. However, when I perform a calculation it fails with the error "This network cannot be solved. Please check your network or specifications".

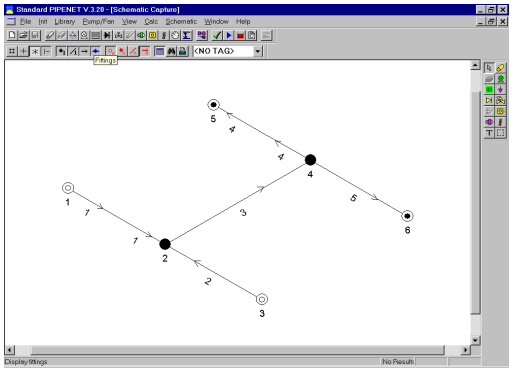
The specification rules state that the total number of pressure and flowrate specifications must equal the number of ionodes in the system. However, although the overall network may appear to obey this rule, discrete areas of a network may be over-specified or under-specified. Such areas will cause a calculation to fail.

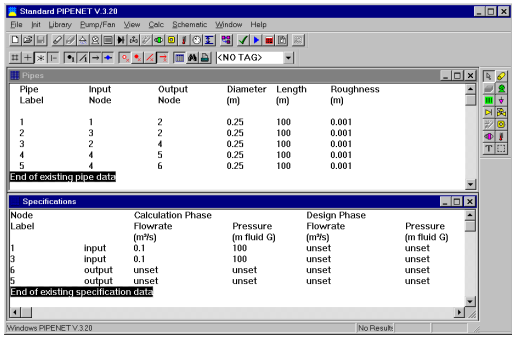
When performing a calculation PIPENET assembles a series of simultaneous equations that it must solve to find flows and pressures throughout the network. In order for this method to succeed, PIPENET must be able to create as many equations as there are unknown parameters. None of these equations may be linearly dependent.

In PIPENET, the linear dependence of equations is checked after a calculation is attempted, and not when the "Check" button or "Check" menu option is selected. Hence a network may pass the "Check" phase successfully, but fail the calculation phase.

Consider the simplified example presented below. This network appears to satisfy the specification requirements. There are four ionodes: 1, 3, 5 and 6, and the same number of flowrate and pressure specifications. Ionodes 1 and 3 have flow and pressure specifications, whereas ionodes 5 and 6 are left unset. When a check is performed, the check status indicates that pipes and nodes have been specified adequately. However, the calculation fails.

The network is under-specified in one area and over-specified in another.

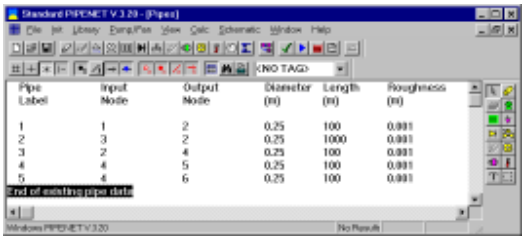




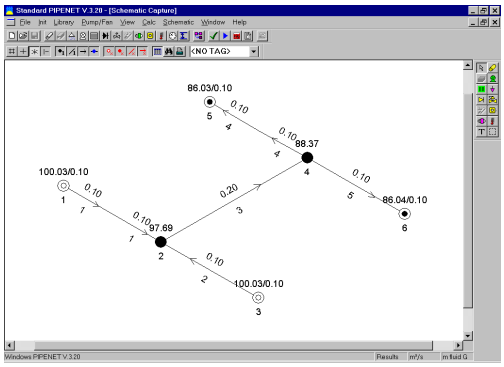
Consider the area of the network defined by nodes 4, 5 and 6. It is not possible for the model to determine the distribution of flow into pipes 4 and 5 at node 4. This sub-network is therefore under-specified.

Now consider the area of the network defined by nodes 1, 2 and 3. Four pressure and flow specifications are provided at nodes 1 and 3, but these were not all needed to calculate the pressure at node 2. If pressure and flow specifications had been provided at node 1 only, it would have been possible to derive the pressure and flow at node 2. This sub-network is therefore over-specified.

In this case the specifications given at node 1 do not contradict those at node 3. The pressure calculated at node 2 would have been the same whether the specifications at node 1 or node 3 had been used to derive it. However, the attributes of pipe 1 or pipe 2 could now be amended so that the network and specificaations in this area are no longer consistent. Such a combination of pipe data is shown below. This area of the network is now over-specified. PIPENET will be unable the determine the pressure at node 2.



To solve the problem a specification must be removed from node 1 or 3, and a specification must be placed on node 5 or 6 as shown below.



Q2. After installing the PIPENET module and inserting the security key I get an error message stating that the security key is not present.

Prior to installing the PIPENET module you should check the following.

1 Terminate any other PIPENET applications that may be running – although this is not generally necessary, it is probably best to eliminate as many potential conflicts as possible.

2 You must have Windows' Administrator privileges to install the key drivers since changes are made to the System Registry. Contact your IT department if you are unsure of this, or if you require your privileges to be changed.

3 Check that you have read and write access rights to the drive where the software will be installed (by default C:) and where the temporary files will reside (also by default drive C:). This is necessary since some organisations prohibit their users from accessing the local disk and selected network drives, other than for read. Again if you do not have these rights then you will have to contact your IT department.

4 If you are using Windows 95 or 98 remember to re-boot the system immediately following installation of the software.

You can check whether or not the necessary drivers are installed by entering the following command in a DOS window or from the Start – Run menu option:

<path>\keydriver\hinstall

where <path> is the installation path for the PIPENET software.

If the drivers are correctly installed then this should report this fact together with the installation date. If the command reports that the drivers are not installed then it is almost certainly due to one of the checks above failing.

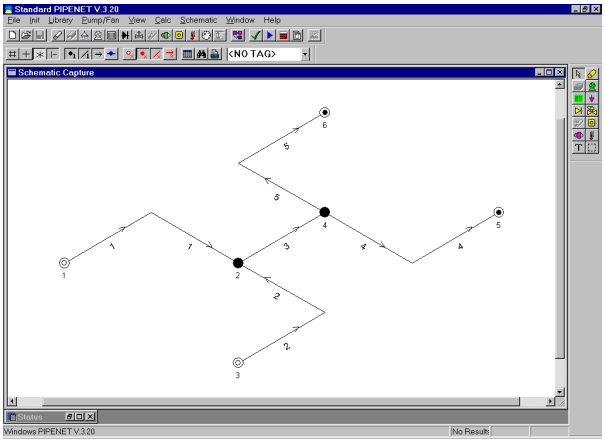
Q3. How can I model a leak using PIPENET?

This option is only available in the PIPENET Standard Module and can only be used when the fluid is a gas. The modelling equation states that the pressure drop across a leak is dependent on the flow rate through the leak and on the area of the leak. The area of the leak is the cross-sectional area through which the fluid is leaking.

A typical example is a leaky door in a ventilation system.

Q4. How can I model blocked pipes in PIPENET?

In PIPENET a pipe can be modelled as normal, blocked or broken. By default, all pipes are normal but users have the facility to simulate a pipe as being broken or blocked. This is a very useful and powerful feature of PIPENET but users must be aware that this may lead to two separate disjoint networks that may become insoluble as a result. If this happens then the program will give the error message: "This network cannot be solved. Please check your network or specifications".



Consider the simple network above. We have four ionodes: 1, 3, 5 and 6. Nodes 1 and 3 are input nodes with pressure specifications, whereas nodes 5 and 6 are output nodes with flow rate specifications. Without any blocked pipes, the simulation will run successfully but if we were to block pipe 3, then the simulation will fail to run. The simulation fails to run with a blocked pipe because the network splits into two, and the isolated network containing specifications 5 and 6 do not have any pressure specifications.

Blocked or broken pipes are shown on the schematic display with dotted lines.

In PIPENET, in order to have a successful calculation, a network must have at least one pressure specification and the number of ionodes must be equal to the number of specifications.

Next Issue

The next issue will include more of the regular sections "Case Studies" and "Frequently Asked Questions". We will also describe, in more detail, the revised suite of modules which are due for release in 2001.

We always welcome any contributions to the newsletter from our users. In particular we would like to receive more case studies such as those we have already featured in this and previous newsletters.

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Transient Module Version 5.00

A major new feature in the new version of Transient Module is the introduction of a schematic facility. This is described in more detail later on in this newsletter.

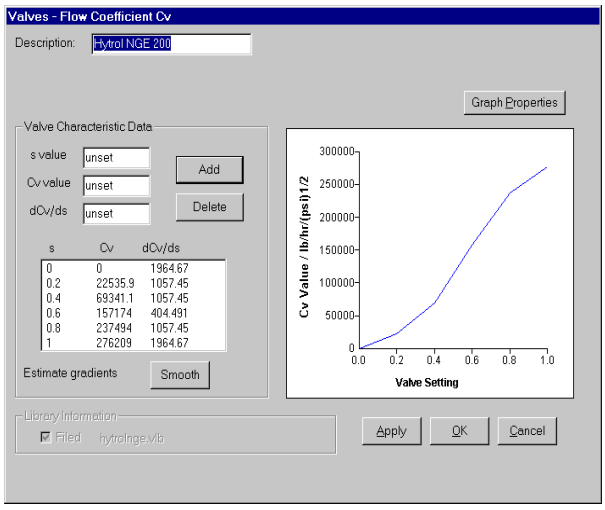
The new release includes a number of other new features. As well as the features described in this section, Transient Module Version 5.00 includes the following enhancements:

- 32 built-in pipe schedules (ANSI, JIS and DIN) in STAND option.
- Number of tags increased to 250.
- More detailed output information on component state switches.
- Online Help facility introduced.

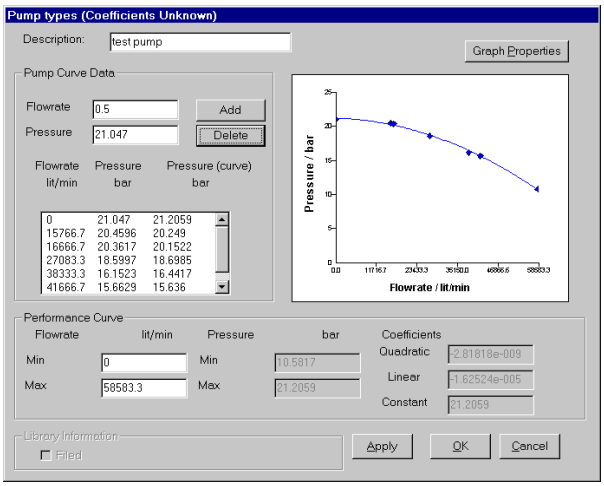
Graphical Display of Pump, Valve and Specification Curves

A new graphical display of pump, valve and specification curves is a major enhancement in the new release. This provides a better visual display of the data being entered.

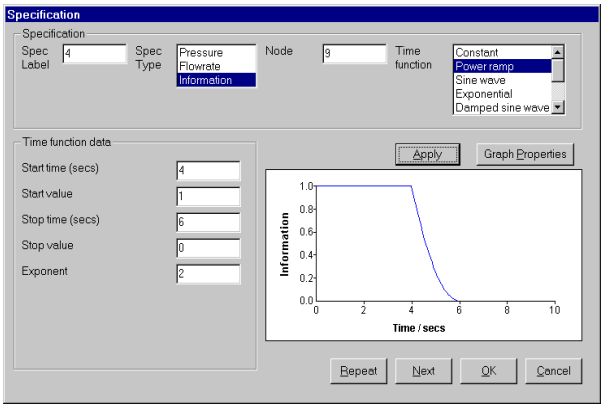
An example of a C_V characteristic curve for a valve is shown below:



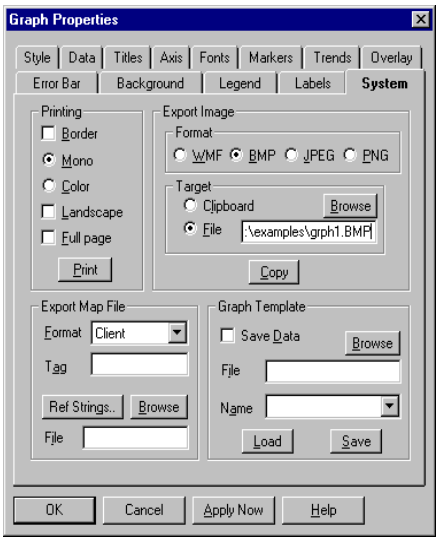
The pump library (coefficients unknown) graph shows the profile data points along with the fitted quadratic pump curve:



For specification curves, the x-axis range is between the simulation start and stop times:



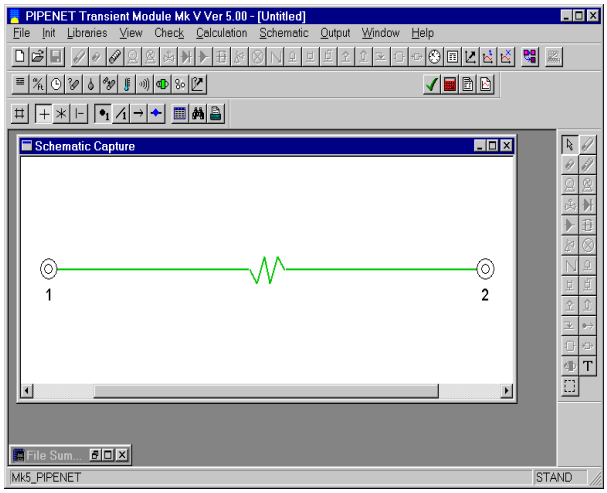
The properties of the graph can be altered by selecting **graph properties**. This displays a wide range of tabbed options for editing the graph. The graph can even be copied to the clipboard or saved to a graphics file for later use in a project report by selecting the **System** properties tab (right).



Transient Module
Version 5.00 (continued)

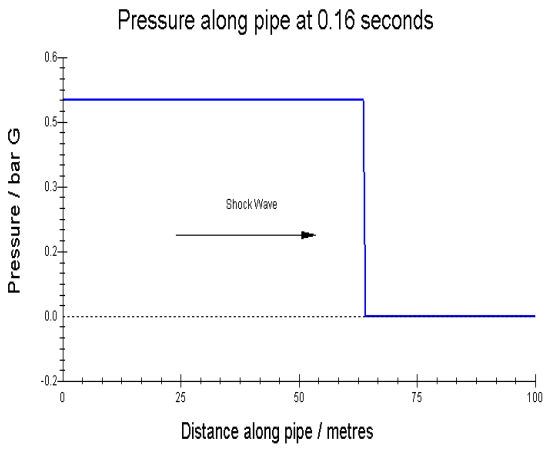
Compressible Flow Pipe Model

The latest release of Transient Module includes a new model designed to calculate compressible gas flow in a single pipe. The schematic representation of the compressible pipe is shown below:

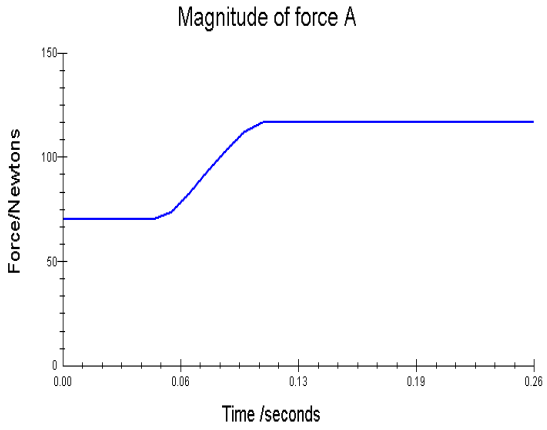


The Compressible Flow Pipe has been designed with one particular application in mind. Relief valves are often used to protect vessels containing hazardous fluids. They tend to open very rapidly which causes a sudden increase of pressure at the inlet of the attached pipe.

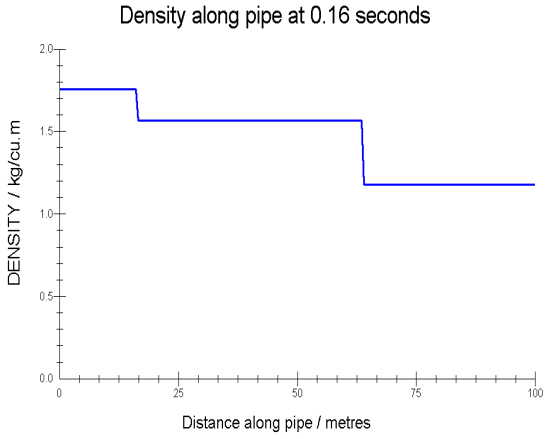
This leads to a shock wave travelling down this pipe (below).



The forces associated with such a shock wave can be quite substantial and can damage the pipe or its support. The Compressible Flow Pipe has been designed for the analysis of such a situation. The pipe can have bends, and the forces on these can be computed.
Of particular interest are forces on double 90^{O} bends.



Results for the gas density are also available to the User:



In summary, the Compressible Flow Pipe:

- Computes an analytical solution of the first path of a shock wave.
- Must be connected to pressure specification at both ends.
- Must have a specified inlet pressure greater than the specified outlet pressure.
- The simulation automatically stops when the shock wave reaches the outlet.

Improved Valve Models

Inertial Check Valve

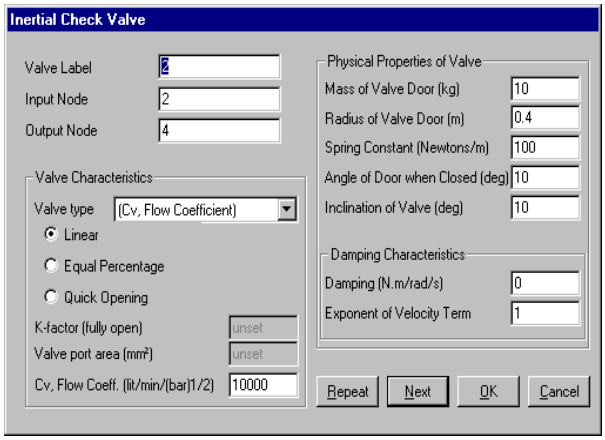
The Inertial Check Valve has been modified to include parameterised damping. The valve torque equation now includes a new term:

$$\mathbf{k}.\omega^{\mathbf{n}}$$

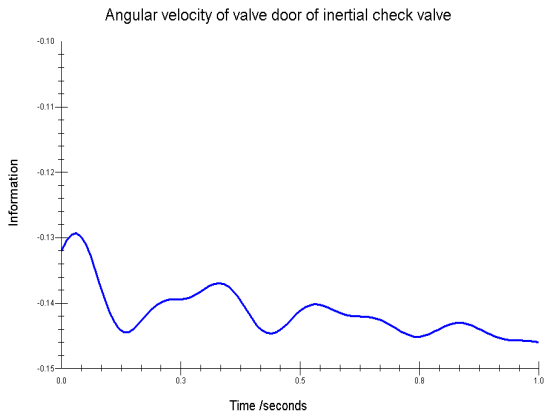
where

ω is the angular velocity of the valve door,
k is the damping coefficient,
n is the damping exponent.

The new valve dialog is shown below:



The default value for damping coefficient is zero corresponding to no damping. This ensures compatibility with previous versions of Transient Module.
The default value for damping exponent is one corresponding to linear damping. Non-linear damping can be modelled by including a different value.



Check Valve

The Check Valve model has been improved so that valve closure is more realistic.

Liquid Surge Relief Valve

The Liquid Surge Relief Valve has been improved in Version 5.00 of Transient Module. It now includes optional hysteresis which allows the User to model relief valves more realistically.

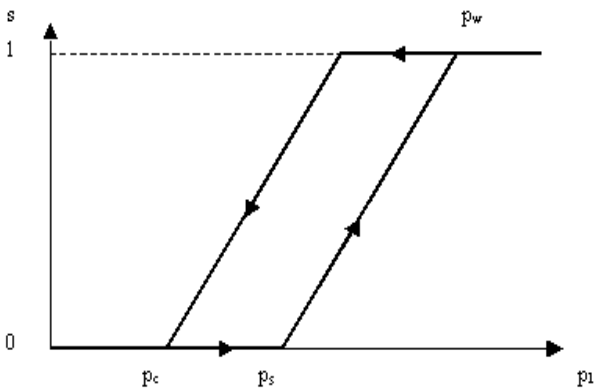
The Relief Valve parameters are:

Set Pressure:
The pressure at which the valve starts to open.

Wide Open Pressure:
The valve is fully open when the inlet pressure reaches this value.

Closing Pressure:
New in Version 5.00. The valve remains fully open until the inlet pressure drops by the difference between the Set Pressure and the Closing Pressure.
As a result the valve will be fully closed once the inlet pressure drops to the Closing Pressure.

This hysteresis is shown below.



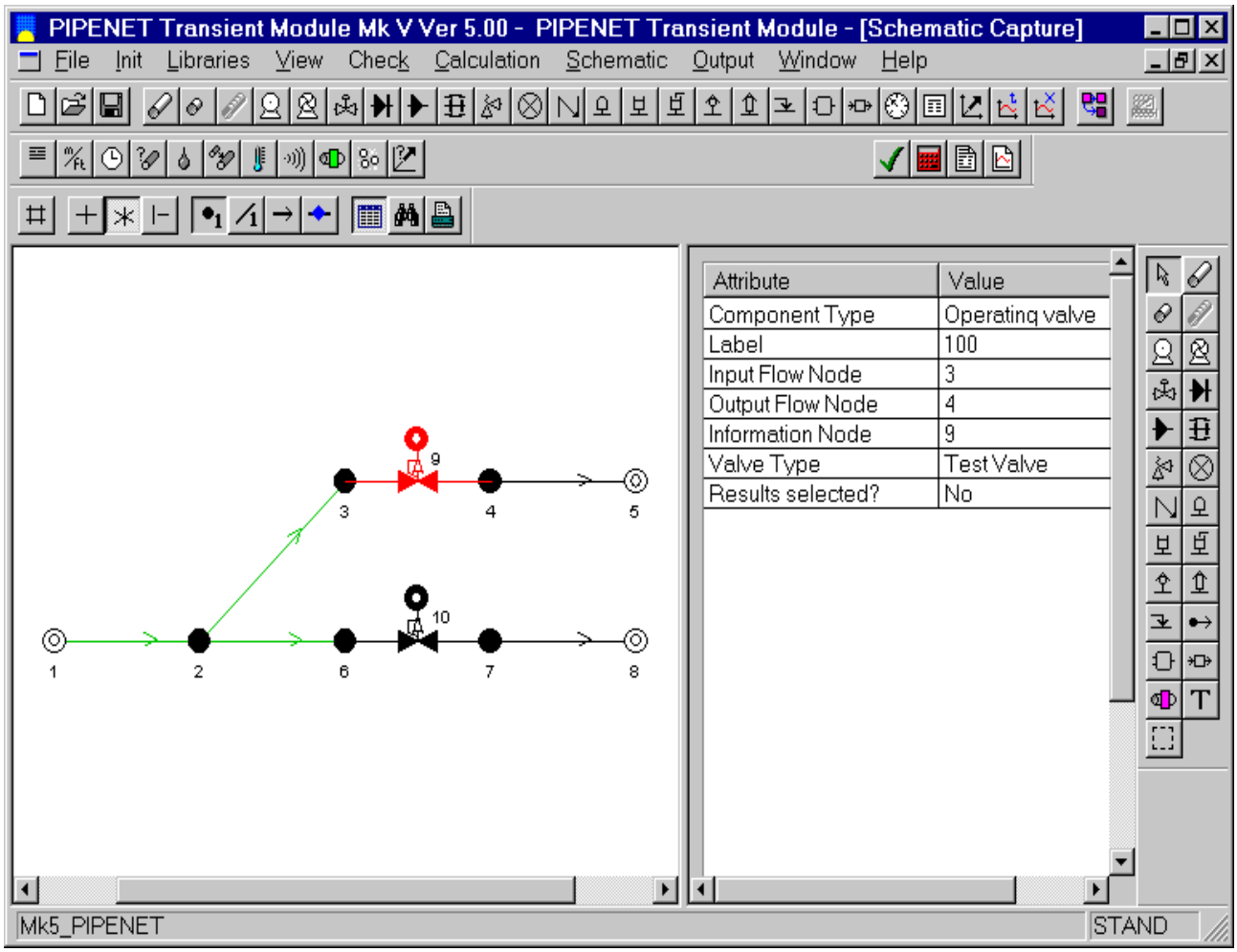
Compatibility with previous versions of PIPENET™ Transient Module is ensured by a default setting that corresponds to no hysteresis.

Transient Module Schematic Option

The schematic feature introduced in the Standard and Spray/Sprinkler modules earlier this year (see issue 2 of this Newsletter) is now available in Transient Module Version 5.00.

This new release incorporates all of the schematic features found in the Standard and Spray sprinkler modules, including the new features introduced with Version 3.10 of these modules. The schematic facility also incorporates a number of facilities specific to Transient Module, for example those relating to Transient control loops and the display of graphical results.

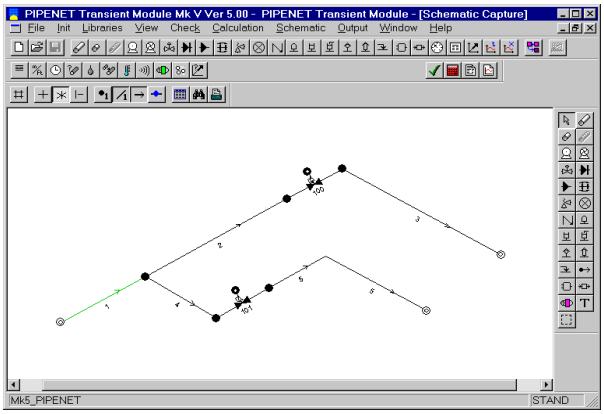
The same philosophy has been adopted in the provision of a schematic capability for Transient in that networks can be entered and edited via the schematic window, or as before, using text entry. This means that on activating the Transient module it will appear and behave exactly as it did in earlier versions. It is only on opening the schematic window that the power of this new facility becomes apparent.

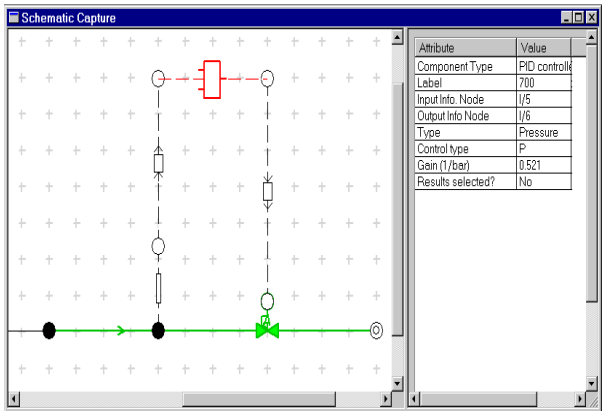


If an old .DAT file is opened then the schematic will use its best efforts to arrive at a representation of the network. The display obtained by opening the forces example and then opening the schematic window is shown above.

Further editing may be required to achieve the optimal layout. To assist in the layout of the schematic, nodes may be constrained to lie on a grid using ‘snap to grid’. Two grid systems are provided: an orthogonal grid and an isometric grid.

Editing the forces example and constraining nodes to lie on an isometric grid produced the schematic representation shown right:

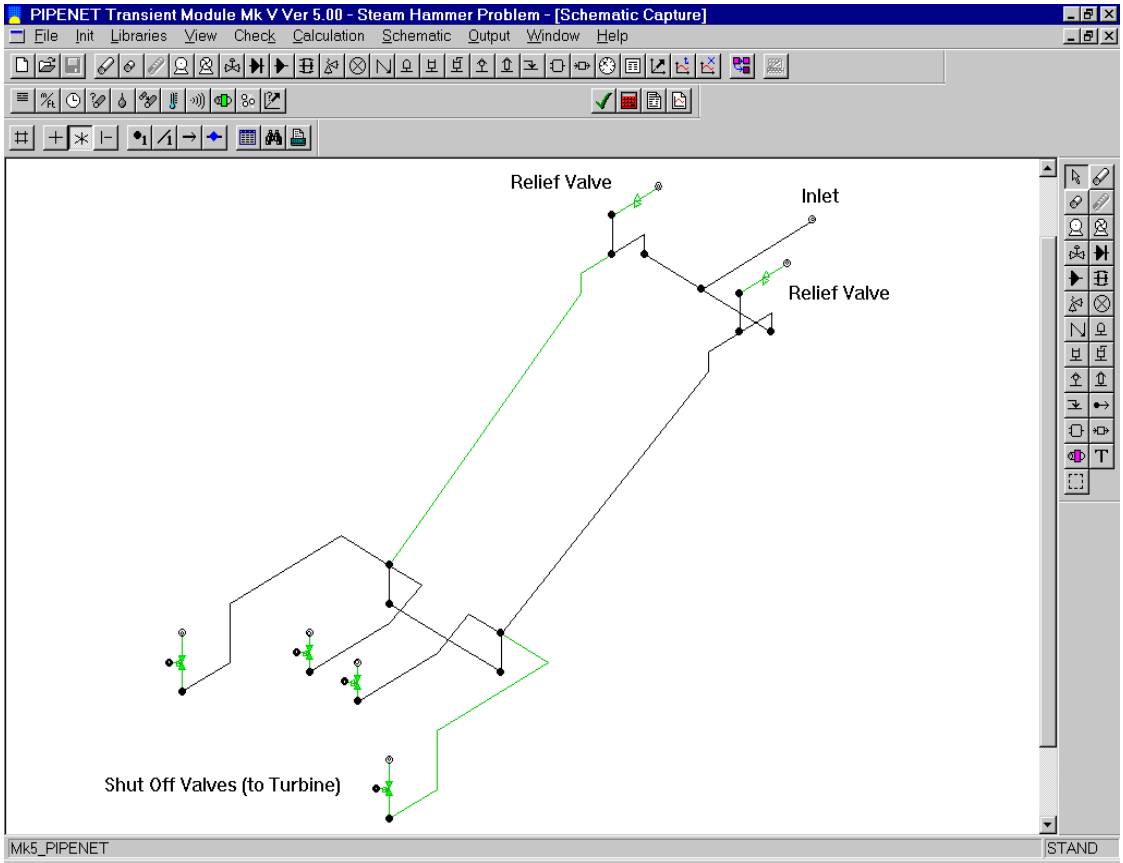

PIPENET Transient Module Mk V Ver 5.00 - PIPENET Transient Module - [Schematic Capture]
File Init Libraries View Check Calculation Schematic Output Window Help
Mk5_PIPENET
STAND



The picture shown left illustrates a more complex example that includes control loop components. These are drawn using dotted lines to distinguish them from flow components. Here the reading from a pressure sensor controls a valve.

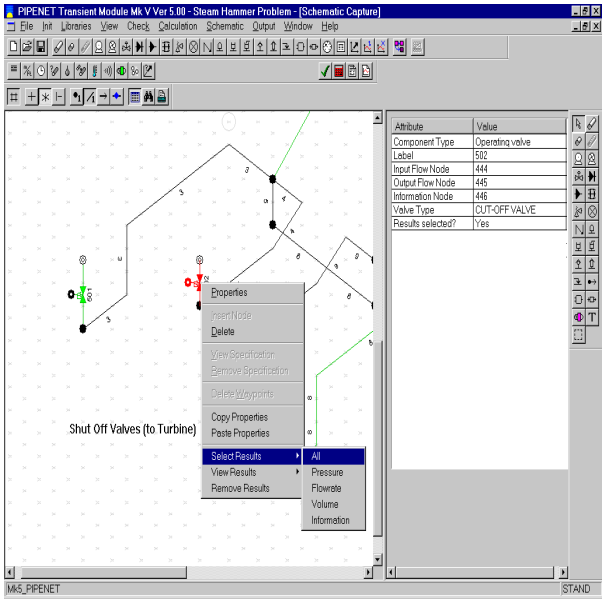
Components with associated results are highlighted in green on the schematic and simply by right-clicking on a component the graphical results may be selected for display.

Below we show a more complicated steam hammer example, represented in isometric view. The grid itself is not shown here for reasons of clarity.


PIPENET Transient Module Mk V Ver 5.00 - Steam Hammer Problem - [Schematic Capture]
File Init Libraries View Check Calculation Schematic Output Window Help
Relief Valve
Inlet
Relief Valve
Shut Off Valves (to Turbine)
Mk5_PIPENET
STAND

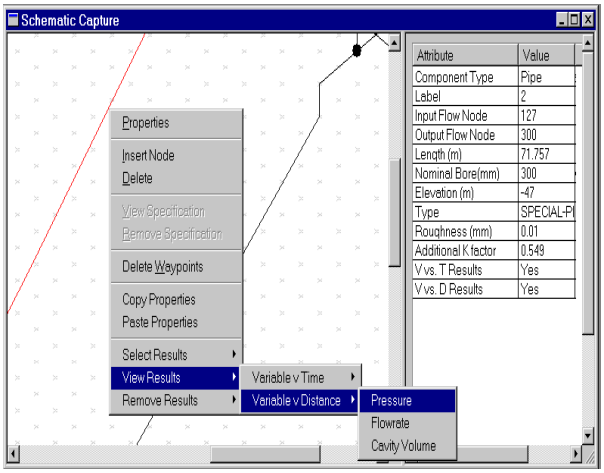
Output graphs can be chosen from the menu option or, more easily, directly from the schematic.
Right mouse clicking the component and then choosing the **Select Graphs** option ensures graphical results are available for that component.

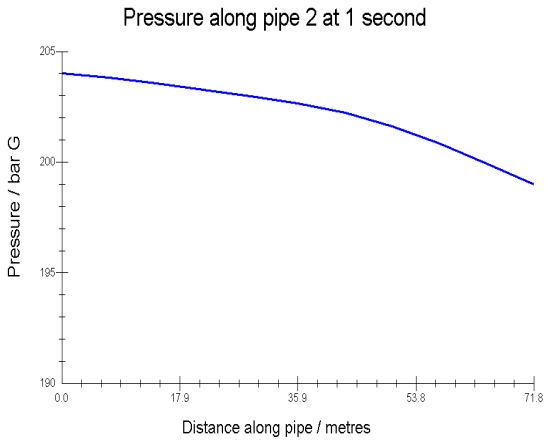
In the diagram (right) all results for one of the Shutdown valves have been chosen. Note the presence of the (optional) side window which displays properties of the selected component and also shows whether results are selected for the component.



Once the simulation has completed graphical results can be selected directly from the schematic window. If the Graph Viewer isn't already open it will automatically open and plot the requested graph (if the results are available).

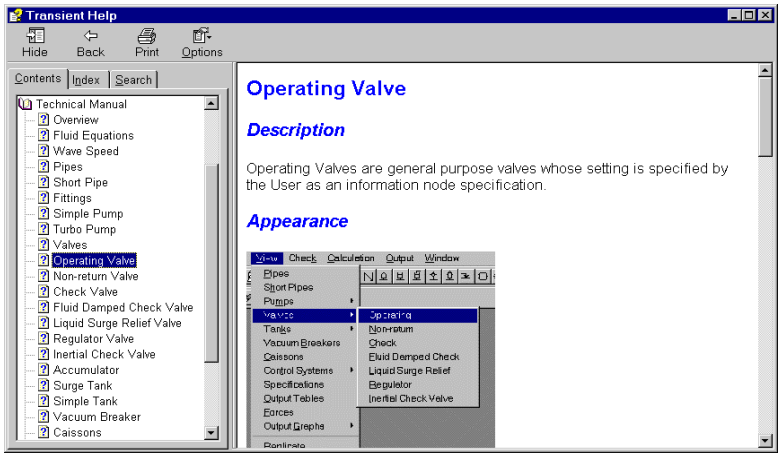
Simply right-click and choose one of the **View Results** options. Below right is the graph of pressure along pipe 2 (from the shutdown valves to the steam header) at 1 second:





Full On-line Help is now provided with the Transient Module.

This includes material from both the User and Technical Manuals (see right).



Case Study

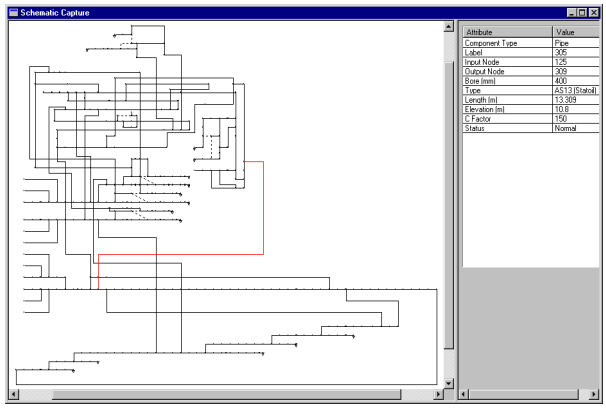
Aker Maritime (AOGT) successfully develop the Gullfaks C fire fighting system models for steady state and transient analysis using PIPENET™ Spray Sprinkler Module.

Aker Maritime are undertaking the GCM Modifications for Gullfaks C as part of the GFSAT Satellite Phase II development project. The tie-in of GFSAT phase 2 incorporates a well stream transfer from GFS, Brent subsea template to GFC through a total of three new pipelines, (two production and one test line). These pipelines are pulled through existing J-tubes on GFC.

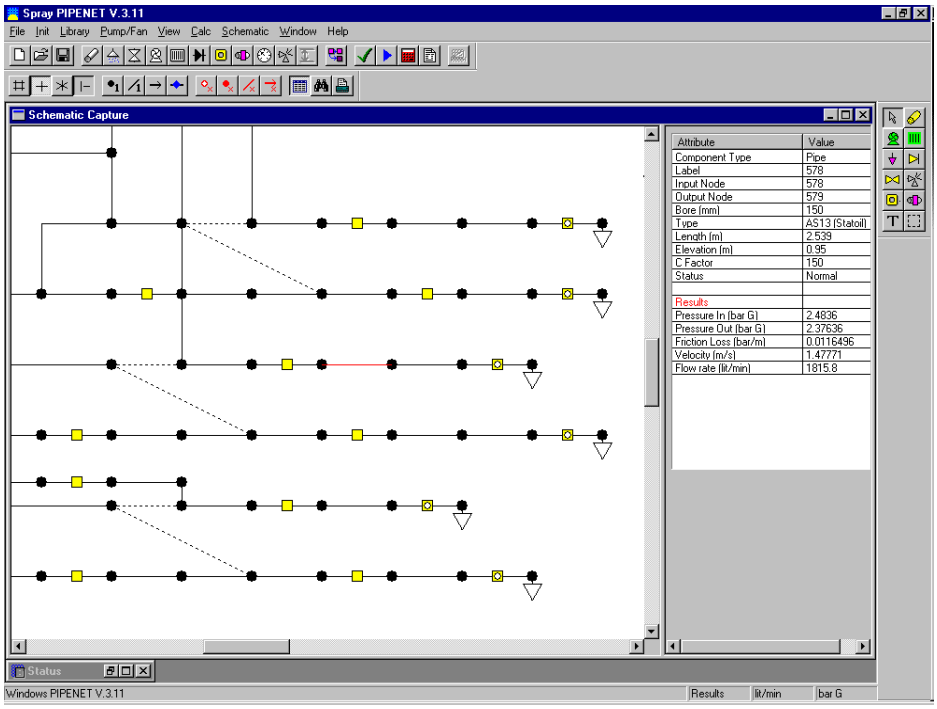
The two new subsea templates on GFS, Brent – L and M will produce two new 14" pipelines. The incoming 14" pipelines will be routed to the new Production Wellhead Module M19, installed adjacent to the existing south wellbay module M17. The test and production lines are tied into production manifolds. A new production line will then feed an inlet separator in the new Process Separation Module M10, installed adjacent to the Gas Treatment Module M14. From the inlet Separator the hydrocarbon fluids are processed within the existing process trains.

Gas processing, Compression and Export facilities will be modified and upgraded to process sales gas into the Statpipe system to a capacity of 16.1MSm^3/d.

In adding the new modules on to Gullfaks C the Design Accident Dimensioning Load (DADL) will be increased. The existing worst case scenario will increase with the addition of the new Module M19.



Aker Oil and Gas Technology UK plc (AOGT), who are undertaking the topsides design and engineering, had at first to develop a model of the firewater ringmain and each of the deluge systems. This was undertaken by firstly converting the existing analysis reports to PIPENET™ format. The converted files were then verified and confirmed against as built information.



From the analysis that was undertaken using PIPENET™, AOGT were able to set the duty point for the new DADL. This was determined as being 2800m³/hr at 19.1 bar at the discharge flange. The existing firepumps are being refurbished and upgraded to meet this new demand.

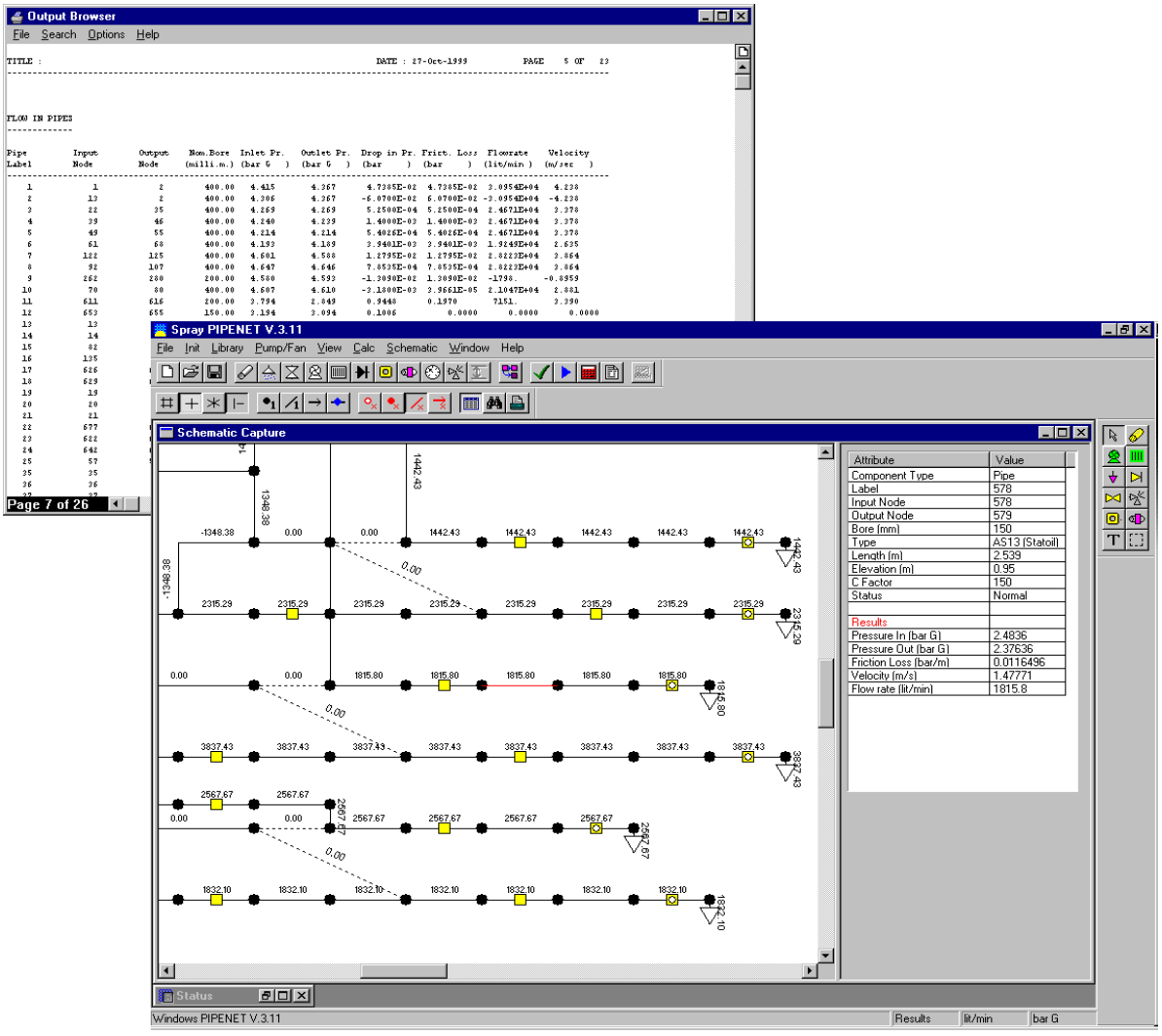
By using PIPENET™, AOGT have been able to identify areas within existing deluge systems where the hydraulic gradient is being constrained by undersized piping. We are undertaking to rectify these piping anomalies with a resultant saving in firewater demand of over 20%.

The PIPENET™ Spray Sprinkler Module by Sunrise Systems has played a major part in enabling AOGT's Fire Protection Engineer to complete this work in a very short timescale. The program is running on a desktop PC using Windows 95™ which allows the responsible engineer to benefit from working in a multi-tasking environment.

The complete library of data and output files will be presented to Statoil for their future use.

AOGT are now undertaking a review of the transient conditions within the ringmain post modification. This will allow AOGT to determine the best solution required to reduce surge overpressures to an acceptable level.

This article was written by Mr S.B. Horn and has been reproduced with the kind permission of Aker Maritime



Frequently Asked Questions

This is a new section featuring answers to common questions and enquiries about using PIPENET™ products.
We hope this section will prove useful to our Users increasing both productivity and enjoyment when using PIPENET™.

Q1. Having used blocked pipes in a network, I get the following error messages: 'Error in Equation n' or 'This network cannot be solved'.

A feature of PIPENET™ Standard and Spray Sprinkler Module is to allow users to simulate calculations with blocked pipes.
The User should be aware of two possible consequences of using blocked pipes:
1. A blocked pipe may split the network into two separate disjoint networks. Each network must have at least one pressure specification, and also have the correct number of specifications, for the calculation to be successful.
2. During the calculation, PIPENET™ replaces each blocked pipe with two extra specifications of flow rate equal to zero. It is therefore possible for an inconsistency in flowrate specification to arise when using blocked pipes.

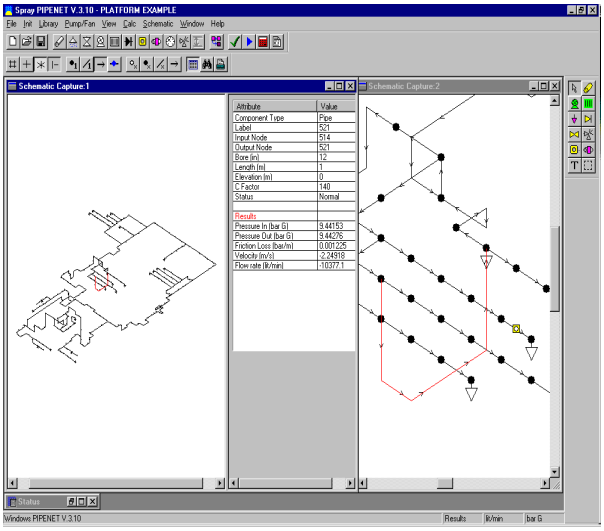
Q2. What does it mean if I get a node height error when I perform a check or a calculation? And what can I do about it?

A node height error will be detected if pipe elevations are specified and the pipe network contains one or more loops. A check is made on each loop to confirm that the sum of the elevation changes is zero, plus or minus the default **height check** tolerance. If not, a node height error will be reported.
The default setting for the height-check tolerance is 0.5m. In most situations this setting is adequate, however sometimes it is necessary to increase the tolerance by selecting:
- **Calc | Spec for Calculation** in Standard and Spray Sprinkler Modules
- **Calculation | Controls** in Transient Module

Increasing this will usually solve the problem, if not height elevation changes must be checked.

Q3. How can I simplify the use of the schematic with large networks?

Remember that two or more schematic windows can be open at the same time. These may be displaying different regions of the network and can be at different scaling factors (see below). See the on-line help for further details.



Q4. Why does the calculation for my network fail to converge or why is the solution not what I expected?

In complex networks the calculation may fail to converge in the default number of iterations (50). Increasing the number of iterations (try 250 in the first instance) will usually solve this problem. If the solution is not what was expected then increase the accuracy by changing the convergence tolerance (default 0.001) to a small value, say 0.00001.
The number of iterations and the tolerance are set in
- **Calc | Spec for Calculation** in Standard and Spray Sprinkler Modules
- **Calculation | Controls** in Transient Module.

Q5. Why when I select the Help option is no help displayed?

The PIPENET™ modules all use the latest HTML Help facilities provided by all new Microsoft™ applications. This form of help is based on the use of a Web Browser program that must be installed before the Help facility can be activated. To obtain the full benefits of HTML Help it is recommended that Microsoft Internet Explorer 5 be installed. This is now provided on CD-ROM releases.

CD-ROM Releases

PIPENET™ releases are now available on CD-ROM. This makes the installation process faster and more User-friendly.

In addition, we are now able to include far more information with the release including:

- ***All three PIPENET™ Modules.***
  (note PIPENET™ will only run with a suitably licensed security key)
- ***Self-running demos:***
  Sit back and enjoy the self-running demo versions of Standard, Spray Sprinkler and Transient Modules.
  These introduce the key features of each module and show clearly how to set up typical problems.
- ***Interactive demos:***
  If you are interested in any of the other PIPENET™ products why not try running the interactive demos. These provide all the functionality of the full versions apart from the ability to perform calculations and save data files.
- ***Manuals:***
  User and Technical manuals (in Adobe Acrobat format) for the three PIPENET™ modules.
- ***Case Studies:***
  Examples of real-life problems solved by the three PIPENET™ modules.
- ***Newsletters:***
  Recent issues of this newsletter.

ISO 9001

Sunrise Systems Limited has recently been awarded ISO 9001 certification.
This is recognition of our high level of commitment to quality products and customer service.

Sunrise Systems Web Page

Remember to visit our web page at **www.sunrise-sys.com**. This includes all the latest information on the PIPENET™ releases, as well as a regularly updated 'Frequently Asked Questions' section.

Next Issue

The next issue will include more of the regular sections 'case studies' and 'frequently asked questions'. We will also describe major new development projects being undertaken in the year 2000.

We always welcome any contributions to the newsletter from our Users. In particular we would like to receive more case studies such as those we have featured from Aker Maritime (this issue) and Brown and Root (issue 2).

Enjoy the Millennium celebrations!!

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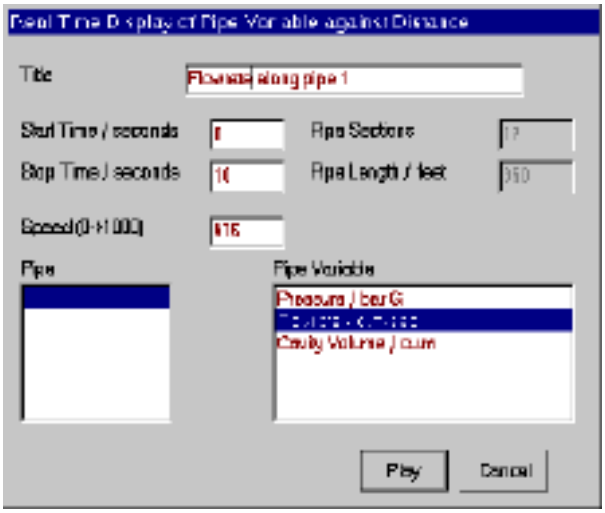
TELEPHONE (01223) 441311 (INT +44 1223 441311) FAX (01223) 441297 (INT +44 1223 441297)
EMAIL: pipenet@sunrise-sys.com WEB SITE:www.sunrise-sys.com

Alternatively the pipe results can be displayed sequentially as a ‘movie’. This can be an extremely useful visual tool for the engineer.



Unfortunately this newsletter cannot do justice to this ‘dynamic’ new feature! But when you receive the new version (or a demo of the new version) you will see that results for pipes experiencing a pressure surge can be quite dramatic, demonstrating clearly the pressure wave travelling along the pipe length.

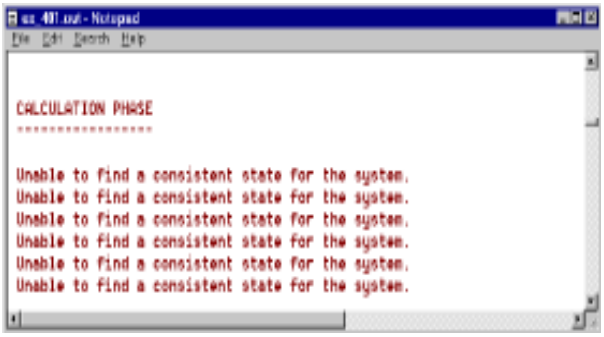
Improved calculation algorithm

Sunrise Systems are committed to continually improving the calculation algorithms used by PIPENET™.

One aspect of the Transient Module calculation that sometimes gave rise to calculation failure in previous versions was that of a component ‘state-switch’.

Certain components in PIPENET™ can experience a state-switch when the nature of the modelling equation changes. Examples include a valve becoming fully closed, and a vacuum breaker starting to draw air into the system.

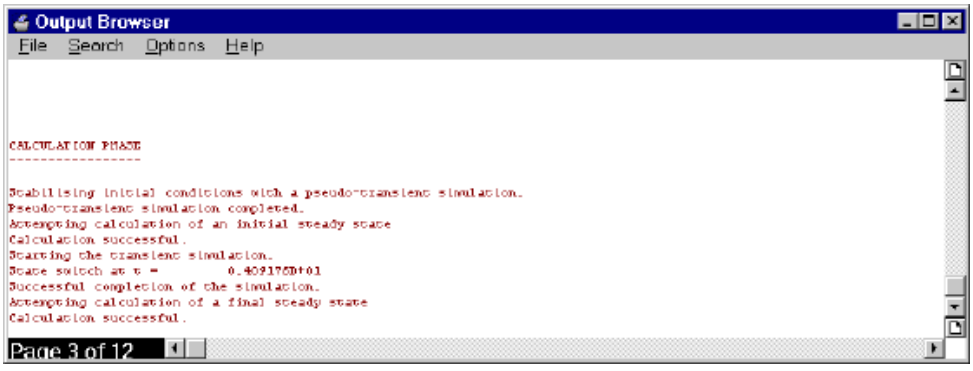
This would sometimes give rise to a calculation failure, and the generation of an ‘unable to find consistent state for the system’ error message in the output report.


CALCULATION PHASE
Unable to find a consistent state for the system.
Unable to find a consistent state for the system.
Unable to find a consistent state for the system.
Unable to find a consistent state for the system.
Unable to find a consistent state for the system.
Unable to find a consistent state for the system.

In the past it was necessary to work around this problem by defining a smaller timestep for the calculation, thus enabling the calculator to resolve the system behaviour when a state-switch occurs.

In the new algorithm the program is able to resolve the system behaviour of the state-switch automatically. In the example above (which failed in the older version) the calculation succeeds in the new version, and the output report gives details of the state-switch (see below).

The new calculator was put through the usual comprehensive test procedures. These included validation of results with an in-house suite of examples, as well as specific customer and Sunrise generated examples designed to focus on particular aspects of the calculation.


Output Browser
File Search Options Help
CALCULATION PHASE
Stabilising initial conditions with a pseudo-transient simulation.
Pseudo-transient simulation completed.
Attempting calculation of an initial steady state
Calculation successful.
Starting the transient simulation.
Successful completion of the simulation.
Attempting calculation of a final steady state
Calculation successful.
Page 3 of 12

The New Schematic Option

Schematic Capture is a new facility available as an option for the latest Standard and Spray/ Sprinkler Modules releases.

A schematic capability for the Transient Module is scheduled for release second quarter of 1999.

Schematic capture can be used:

- As a visualisation tool for existing networks, in this case the facility will generate a schematic representation of an existing network, i.e. one entered in the conventional PIPENET™ manner using text entry.

- As a new and more intuitive means of entering and editing networks.

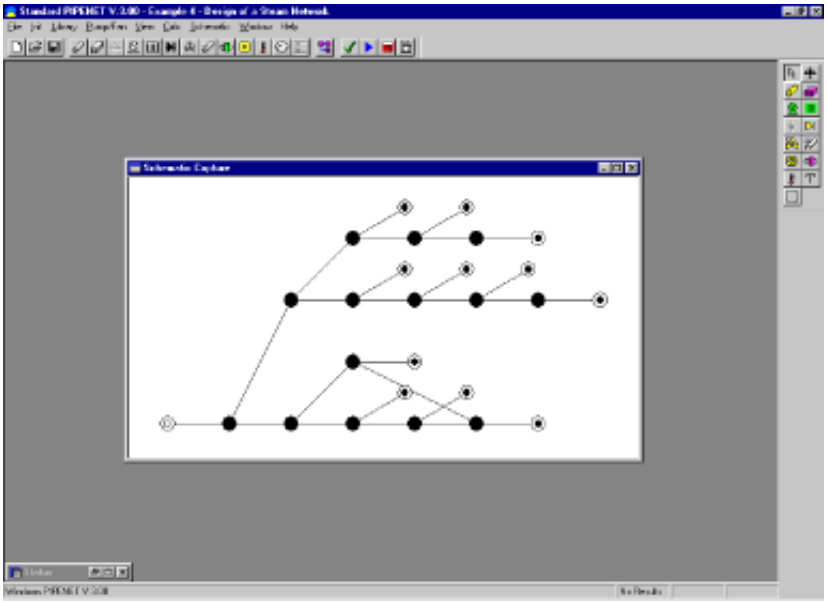
Careful attention has been given to the design of this facility to ensure that it is the users who choose the way they use the facility. Existing users may choose to continue using text entry for some time and only use the schematic capability as a visualisation tool, whereas new users may immediately start using the schematic facility as the normal method of entering and editing networks.

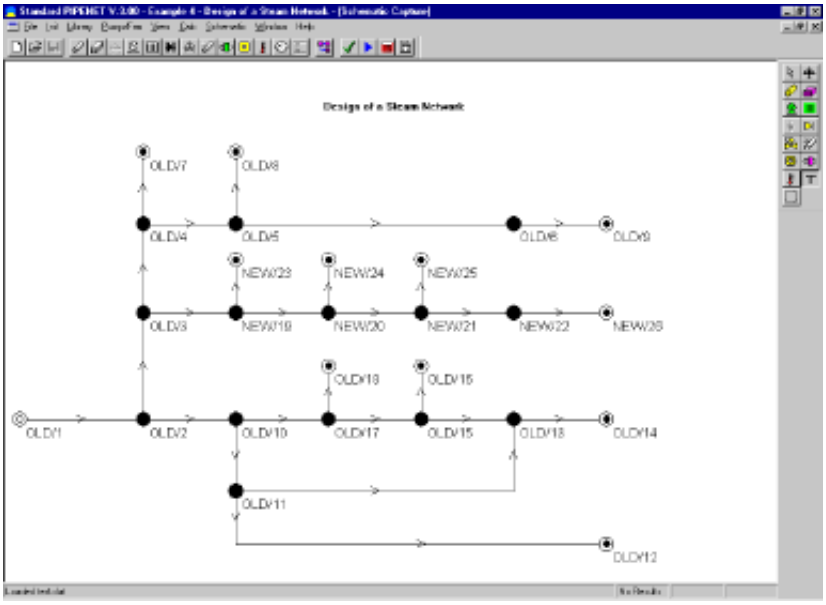
Until the schematic capability is activated the PIPENET™ Standard or Spray/Sprinkler module will behave in exactly the same manner as it did prior to Release 3.00. Specifically networks are entered and edited in the usual manner and all .dat data files remain unchanged. Once you activate the schematic however, all of this changes.

If a .dat file is already open, activating the schematic will immediately open a window with a schematic representation of the network.

Below we see the result of activating the schematic with the Steam Network example supplied with the Standard Module.

The schematic will use its best efforts to arrive at a representation of the network but further editing may be required. Using the mouse and the keyboard nodes can be moved, pipes resized, text annotation added and much more.

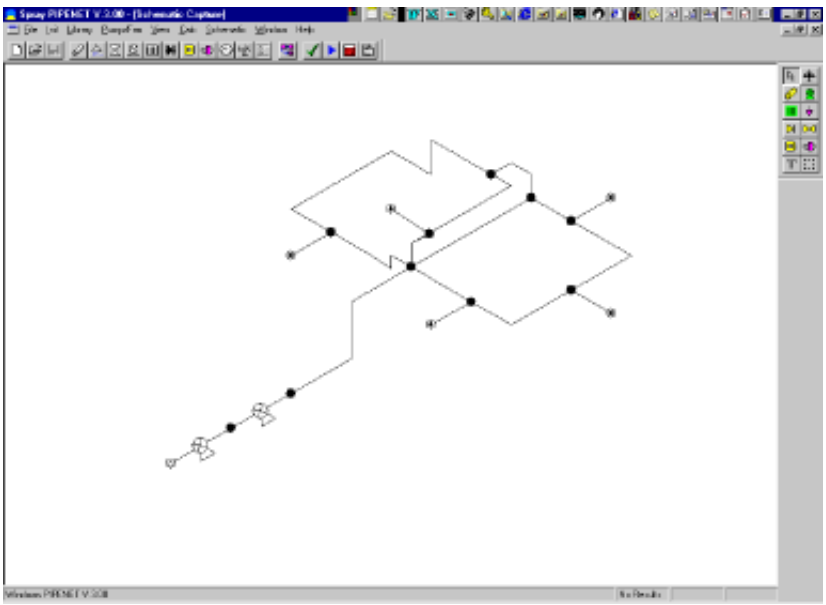




The diagram above shows just a few of the possibilities:

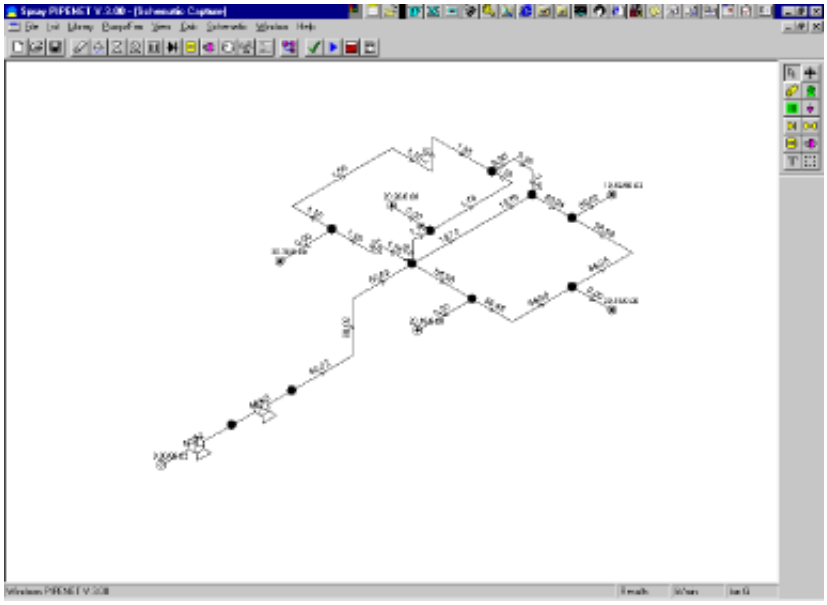
- Node labels and component directions are displayed.
- The crossing pipe in the original diagram has been removed simply by selecting a node and dragging it to a new position.
- The schematic has been zoomed to fit the available window.
- Two pipe runs have been edited by inserting intermediate points (the two outputs from node OLD/11 in the lower part of the diagram). These intermediate points can also be moved just like the Pipenet nodes.
- Text annotation has been used to provide a title for the schematic.

To assist in the laying out of the schematic, nodes may be constrained to lie on a grid. Two grid systems are provided; an orthogonal grid and an isometric grid. The diagram below shows a network displayed on an isometric grid. The grid itself is not shown here for reasons of clarity.



A schematic can be printed via the standard Windows print drivers, using any supported size paper. The printed schematic can be printed on a single page or, for large networks, across a number of pages.

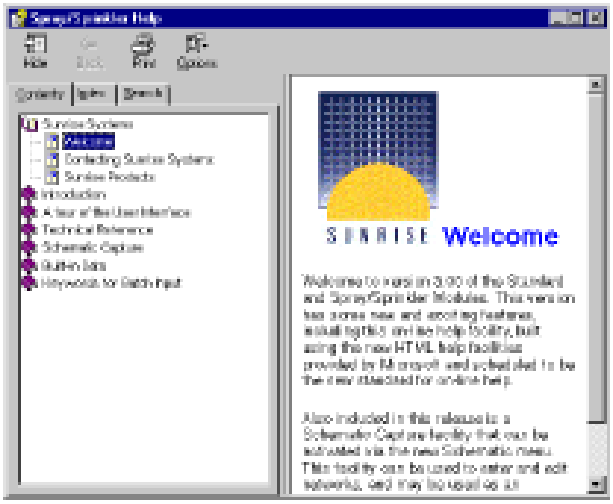
Following a successful calculation, results may be displayed on the schematic. Results can include flow rates, direction of flow, pressure at each node and pressure and flow at all input and outputs. The diagram below shows the flow rates through each component. The units used are displayed on the status line.



To coincide with the release of the schematic, on-line help has been provided for the Standard and Spray/Sprinkler modules.

This on-line help uses the last help technology from Microsoft™ and is identical to that used in the very latest releases of Microsoft™ products and requires the installation of Microsoft™ Explorer, preferably version 4.0 or later. On windows 98 and NT this is built in, for other systems it will have to be installed. Note however, that although Internet Explorer has be installed it does not have to be the default browser used for the customer's internet access.

The diagram below illustrates the appearance of the help window.



Case Study

BROWN & ROOT SUCCESSFULLY MODEL WATER INJECTION SYSTEM USING PIPENET™ TRANSIENT MODULE

12 September 1998

Brown & Root Energy Services are well advanced with the development of the detailed design of the South Anne oil and gas production platform for the client Amerada Hess A/S. This platform will produce 55,000 bpd of crude oil and 70 MMscfd of gas from the Danish sector of the North Sea. To support oil production, it will be necessary to inject deaerated seawater to the oil reservoir at very high pressure (345 barg) and at rates up to 795 m3/h. Economical design dictates that this system operates close to its design pressure limit and so it was recognised that there was a need to check that various operating modes (start-up, shutdown, valve failures) would not lead to generation of excessively high, transient pressures within the system.

PIPENET Transient Module software from Sunrise Systems was selected as the means to carry out hydraulic surge analysis. This software has been validated by Brown & Root and is considered appropriate for hydraulic surge analysis. A typical engineering workstation PC (Pentium processor, 32MB RAM) was used to run the software within the Windows™ 95 environment. This provided the engineer with the benefits of multitasking computer use whilst working with the PIPENET™ program.

A nodal model of the water injection system was first sketched out on paper using piping isometrics as a basis and system components were identified for entry into the PIPENET™ program input. The components included pumps in series, piping pipe fittings and valves.

Pump curve data was entered which was then processed by the software through a curve fitting routine to characterise the curve as a quadratic equation. The pump data is entered into a library file, which can contain numerous pump curves, which may then be referenced by the main program as required. This allowed entry of data representing different configurations of pumps, which was used in the various scenarios simulated. Similarly, pipe diameter and wall thickness data was entered into a pipe library file from which the main program retrieved data as necessary. The software also has its own library of pipe fittings data. All data input is via user friendly windows.

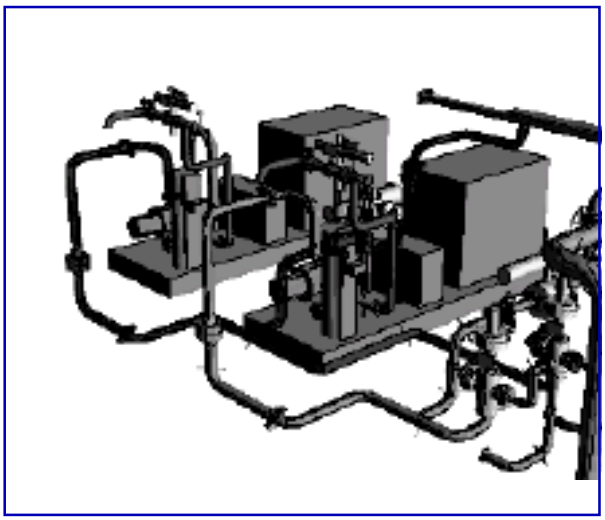
The software model required input of basic data such as pipe lengths, elevation changes, fittings, valve cv's, characteristics and closure time together with boundary conditions of pressure at system inlet (pump suction) and outlet (wellhead). The software can be used to check for input errors before running the program. Once the model was completed, various runs were performed to examine the pressure surges that are generated by scenarios such a simultaneous closure of all wellhead wing valves and during pump start-up. The findings pointed to a need to adjust certain valve closure times to bring peak pressures within the system design maximum allowable.

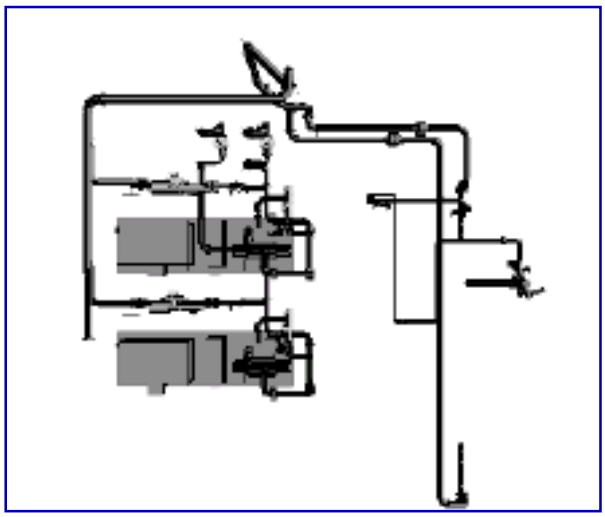
Sunrise Systems provided support during development of the model and program operation enabling a process engineer unfamiliar with the software package to gain useful results quickly. When a problem could not be solved

(continued)

immediately by telephone, the input files were emailed to Sunrise Systems and suggestions for solutions were made in a timely manner.

The diagrams below show two views of the Water Injection System.





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Sunrise Web Page

Remember to visit our web page at www.sunrise-sys.com. This now includes a statement on Year 2000 compliance and information on the latest releases.

Sunrise at ADIPEC

Sunrise were recently represented at the Abu Dhabi International Petroleum Exhibition and Conference. Sunrise attended as part of a delegation headed by the British Minister of State at the Department of Trade and Industry. Sunrise was able to demonstrate its products alongside those of ImageGrafix, COADE and Cadcentre Ltd. This was the first time the four major players in fluid flow analysis, software solutions for the oil and gas industry, Pipe Stress Analysis and Plant Design Management, had joined together to demonstrate the inter-operability of their products.

Next Issue

For the next issue contributions are welcome from users, in particular we would be very interested to receive another case study for inclusion.

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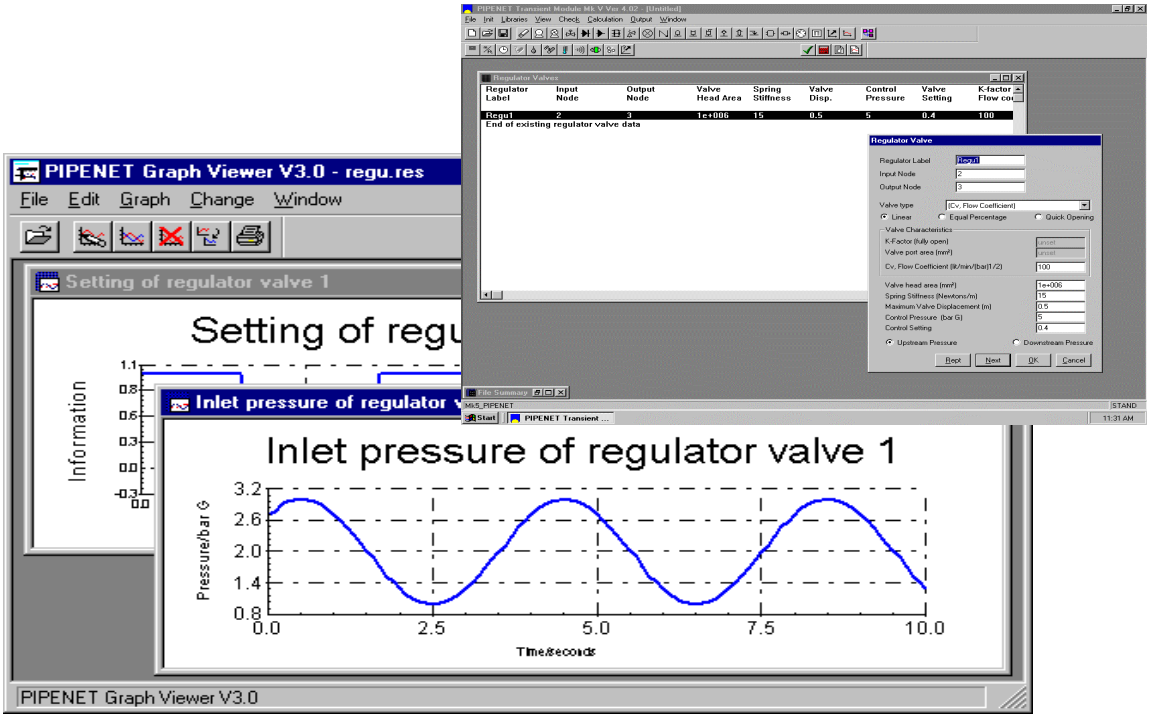


valve models a check valve with additional damping due to hydrodynamic and elastic forces acting on and within the valve.

A number of other improvements have been made following requests for enhancements from our customers. In particular limits for the numbers of pipes and components have been increased, and graphical results are now available to the user in the event of a calculation failure.

- 32-bit Development

A major development to PIPENET™ modules has been the introduction of 32-bit operation. Commencing with the new releases of PIPENET™ modules, all future developments will be targeted for Windows 32-bit operating systems only (that is Windows 95, Windows 98 and NT). The 16-bit versions of the programs running on Windows 3.1 and Windows 3.11 will still be available but with limited support. Existing users of 16-bit systems with Sentinel security key (C-Key) will have to exchange their key for a Hasp key if they plan to upgrade to any of the latest 32-bit systems.

Sending Simulation Data Files by E-Mail

We normally help our customers in tackling difficulties associated with setting up problems in one of our modules. We try to respond as quickly as possible once we have a description of the problem. Some problems can be solved over the telephone but problems associated with complicated networks require us to look at the relevant files. A fast and convenient way of sending Sunrise Systems Limited any problem files is to send the files by e-mail to support@sunrise-sys.com.

A member of our technical team will then be able to recreate and investigate the problem. Outlined below are some of the points to bear in mind when sending data files by e-mail:

- In the covering message, include details of the operating system you are using (e.g. Windows 95, NT 4.0) and the name and version number of the PIPENET™ module.

- It is also helpful to give a brief description of the problem you have experienced and to send a diagram of the network by fax.

- It is not usually necessary to send the output and/or results files for the simulation. These can be quite large and this leads to an expensive transmission time. Provided you send the input file and any supporting library files the output can be recreated at Sunrise Systems Limited.

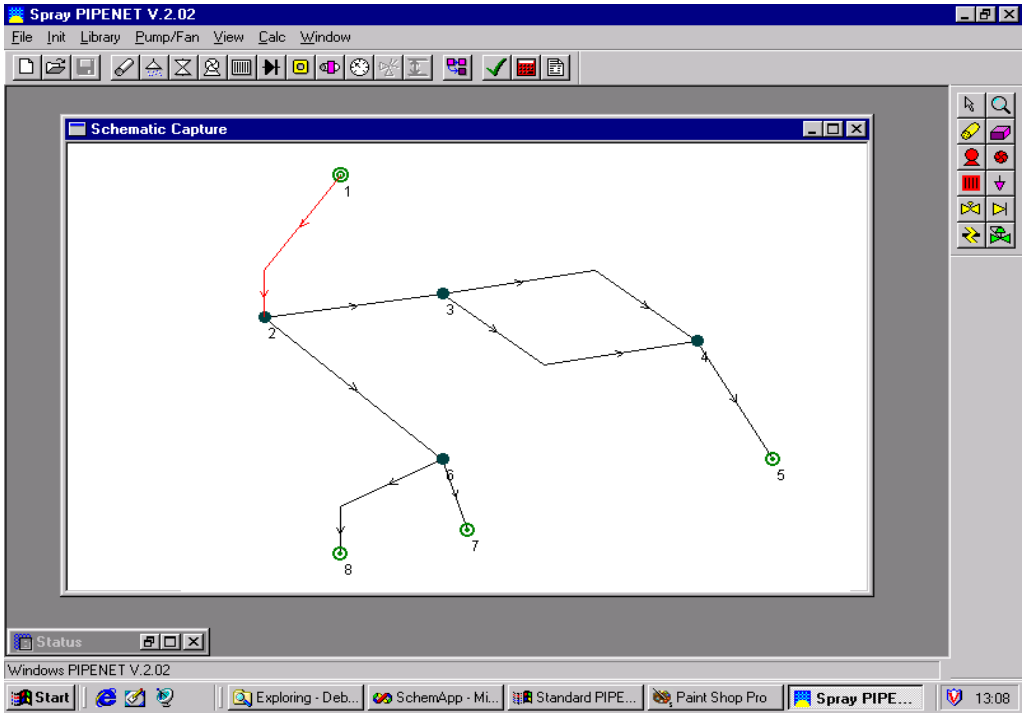
- Any input or library files should be **attached** to, not included in, the covering message. The files should be attached as binary data to prevent file corruption in the transfer process.

Next Issue

In order to demonstrate the full potential and capabilities of PIPENET™ modules, we will discuss a real life problem in our next issue. This will involve contribution from our existing customers. Hence, we would like to hear from our customers who would like to discuss and set up a problem for our next issue.

We are also in the process of incorporating a schematic drawing capability into the existing Standard, Spray/Sprinkler and Transient modules. This facility will enable users to create new networks or edit existing networks in a more visually interactive fashion. Careful attention has been given to the design and representation of the schematic and its integration with the existing modules as shown below. This is to ensure that users will quickly become familiar with its operation and begin to use it as the preferred means of defining networks. All the existing component dialogs and interactions will be retained except that now it will be possible to view the characteristics, of say a pump, by simply clicking on the component's representation in the schematic. More details will be described in the next issue.

For this newsletter to cater for your needs, we welcome some feedback from our readers. We would also welcome any suggestions on articles you would like to see featured in our future issues. For all correspondence, please use the address shown below.



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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 1: Having used blocked pipes in a network, I get the following error messages: 'Error in Equation n' or 'This network cannot be solved'.

Answer: A feature of PIPENET™ Standard and Spray Sprinkler Module is to allow users to simulate calculations with blocked pipes.

The User should be aware of two possible consequences of using blocked pipes:

1. A blocked pipe may split the network into two separate disjoint networks. Each network must have at least one pressure specification, and also have the correct number of specifications, for the calculation to be successful.

2. During the calculation, PIPENET™ replaces each blocked pipe with two extra specifications of flow rate equal to zero. It is therefore possible for an inconsistency in flow rate specification to arise when using blocked pipes.

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LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 2: What does it mean if I get a node height error when I perform a check or a calculation? And what can I do about it?

Answer: A node height error will be detected if pipe elevations are specified and the pipe network contains one or more loops. A check is made on each loop to confirm that the sum of the elevation changes is zero, plus or minus the default height-check tolerance. If not a node height error will be reported.

The default setting for the height-check tolerance is 0.5m. In most situations this setting is adequate, however sometimes it is necessary to increase the tolerance by selecting:

- **Calc | Spec for Calculation** in Standard and Spray Sprinkler Modules

- **Calculation | Controls** in Transient Module

Increasing this will usually solve the problem, if not height elevation changes must be checked.

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LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 3: How can I simplify the use of the schematic with large networks?

Answer: Remember that two or more schematic windows can be open at the same time. These may be displaying different regions of the network and can be at different scaling factors. See the on-line help for further details.

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LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 4: Why does the calculation for my network fail to converge or why is the solution not what I expected?

Answer: In complex networks the calculation may fail to converge in the default number of iterations (50). Increasing the number of iterations (try 250 in the first instance) will usually solve this problem. If the solution is not what was expected then increase the accuracy by changing the convergence tolerance (default 0.001) to a small value, say 0.00001.

The number of iterations and the tolerance are set in

- **Calc | Spec for Calculation** in Standard and Spray Sprinkler Modules

- **Calculation | Controls** in Transient Module.

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LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 5: Why when I select the Help option is no help displayed?

Answer: The PIPENET™ modules all use the latest HTML Help facilities provided by all new Microsoft™ applications. This form of help is based on the use of a Web Browser program that must be installed before the Help facility can be activated. To obtain the full benefits of HTML Help it is recommended that Microsoft Internet Explorer 5 be installed. This is now provided on CD-ROM releases.

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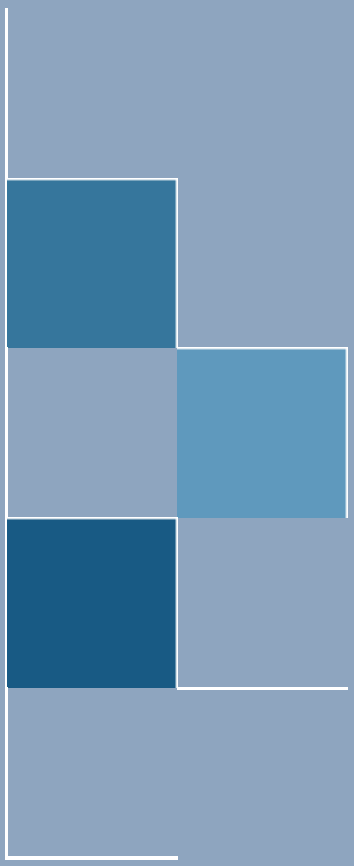

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FREQUENTLY ASKED QUESTION

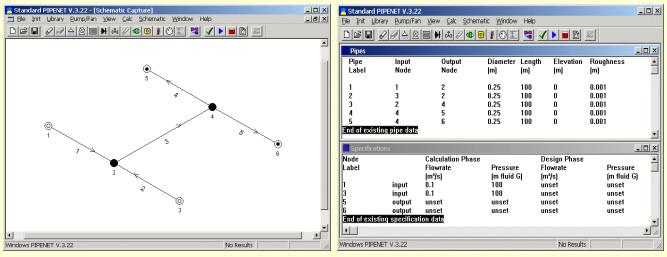
Question 6: I set the required number of specifications in accordance with the specification rules in the manual. A check on the status of the network suggests that all components are adequately specified. However, when I perform a calculation it fails with the error "This network cannot be solved. Please check your network or specifications".

Answer: The specification rules state that the total number of pressure and flowrate specifications must equal the number of ionodes in the system. However, although the overall network may appear to obey this rule, discrete areas of a network may be over-specified or under-specified. Such areas will cause a calculation to fail.

When performing a calculation PIPENET assembles a series of simultaneous equations that it must solve to find flows and pressures throughout the network. In order for this method to succeed, PIPENET must be able to create as many equations as there are unknown parameters. None of these equations may be linearly dependent.

In PIPENET, the linear dependence of equations is checked after a calculation is attempted, and not when the "Check" button or "Check" menu option is selected. Hence a network may pass the "Check" phase successfully, but fail the calculation phase.

Consider the simplified example presented below. This network appears to satisfy the specification requirements. There are four ionodes: 1, 3, 5 and 6, and the same number of flowrate and pressure specifications. Ionodes 1 and 3 have flow and pressure specifications, whereas ionodes 5 and 6 are left unset. When a check is performed, the check status indicates that pipes and nodes have been specified adequately. However, the calculation fails. The network is under-specified in one area and over-specified in another.



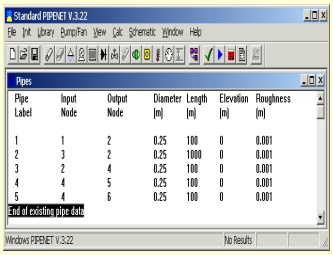
Click diagram to enlarge

Consider the area of the network defined by nodes 4, 5 and 6. It is not possible for the model to determine the distribution of

flow into pipes 4 and 5 at node 4. This sub-network is therefore under-specified.

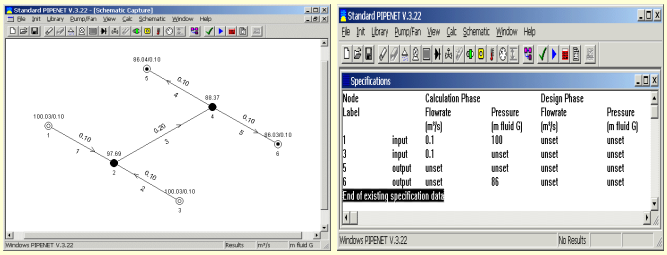
Now consider the area of the network defined by nodes 1, 2 and 3. Four pressure and flow specifications are provided at nodes 1 and 3, but these were not all needed to calculate the pressure at node 2. If pressure and flow specifications had been provided at node 1 only, it would have been possible to derive the pressure and flow at node 2. This sub-network is therefore over-specified.

In this case the specifications given at node 1 do not contradict those at node 3. The pressure calculated at node 2 would have been the same whether the specifications at node 1 or node 3 had been used to derive it. However, the attributes of pipe 1 or pipe 2 could now be amended so that the network and specificaations in this area are no longer consistent. Such a combination of pipe data is shown below. This area of the network is now over-specified. PIPENET will be unable the determine the pressure at node 2.



Click diagram to enlarge

To solve the problem a specification must be removed from node 1 or 3, and a specification must be placed on node 5 or 6 as shown below.



Click diagram to enlarge

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FREQUENTLY ASKED QUESTION

Question 7: After installing the PIPENET™ module and inserting the security key I get an error message stating that the security key is not present.

Answer: Prior to installing the PIPENET™ module you should check the following.

1. Terminate any other PIPENET™ applications that may be running - although this is not generally necessary, it is probably best to eliminate as many potential conflicts as possible.
2. You must have Windows' Administrator privileges to install the key drivers since changes are made to the System Registry. Contact your IT department if you are unsure of this, or if you require your privileges to be changed.
3. Check that you have read and write access rights to the drive where the software will be installed (by default C:) and where the temporary files will reside (also by default drive C:). This is necessary since some organisations prohibit their users from accessing the local disk and selected network drives, other than for read. Again if you do not have these rights then you will have to contact your IT department.
4. If you are using Windows 95 or 98 remember to re-boot the system immediately following installation of the software.

You can check whether or not the necessary drivers are installed by entering the following command in a DOS window or from the Start - Run menu option:

<path>\keydriver\hinstall

where <path> is the installation path for the PIPENET™ software.

If the drivers are correctly installed then this should report this fact together with the installation date. If the command reports that the drivers are not installed then it is almost certainly due to one of the checks above failing.

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FREQUENTLY ASKED QUESTION

Question 8: How can I model a leak using PIPENET™?

Answer: This option is only available in the PIPENET™ Standard Module and can only be used when the fluid is a gas. The modelling equation states that the pressure drop across a leak is dependent on the flow rate through the leak and on the area of the leak. The area of the leak is the cross-sectional area through which the fluid is leaking.

A typical example is a leaky door in a ventilation system.

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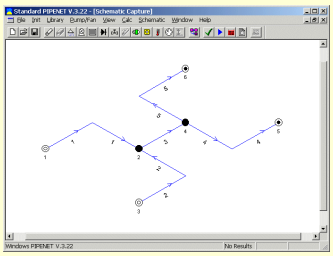
LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 9: How can I model blocked pipes in PIPENET™?

Answer: In PIPENET™ a pipe can be modelled as normal, blocked or broken. By default, all pipes are normal but users have the facility to simulate a pipe as being broken or blocked. This is a very useful and powerful feature of PIPENET™ but users must be aware that this may lead to two separate disjoint networks that may become insoluble as a result. If this happens then the program will give the error message: "This network cannot be solved. Please check your network or specifications".



Click diagram to enlarge

Consider the simple network above. We have four ionodes: 1, 3, 5 and 6. Nodes 1 and 3 are input nodes with pressure specifications, whereas nodes 5 and 6 are output nodes with flow rate specifications. Without any blocked pipes, the simulation will run successfully but if we were to block pipe 3, then the simulation will fail to run. The simulation fails to run with a blocked pipe because the network splits into two, and the isolated network containing specifications 5 and 6 does not have any pressure specifications.

Blocked or broken pipes are shown on the schematic display with dotted lines.

In PIPENET™, in order to have a successful calculation, a network must have at least one pressure specification and the number of ionodes must be equal to the number of specifications.

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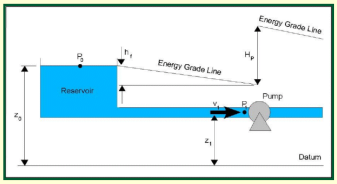
LEADING THE WAY IN FLUID FLOW ANALYSIS

FREQUENTLY ASKED QUESTION

Question 10: What are NPSH and Cavitation Parameter and where can I find out more?

Answer: "Mechanics of Fluids" by B. S. Massey (ISBN: 0748740430) is a good general purpose textbook on the principles of fluid mechanics. It provides a discussion on NPSH and the Cavitation Parameter. This discussion is paraphrased here.



Click diagram to enlarge

Consider a reservoir supplying a pump as shown in the figure. Applying the energy equation between the surface of liquid in the supply reservoir and the entry to the impeller, we have:

$$P_0/\rho g + z_0 - h_f = P_1/\rho g + v_1^2/2g + z_1 \quad (1)$$

where: v_1 and P_1 represent the fluid velocity and static presure, respectively, at the inlet of the pump; z_1 represents the elevation of this point above datum; z_0 represents the elevation, above datum, of the surface of the reservoir; P_0 represents the pressure at the surface of the reservoir, and ρ represents the density of the fluid.

Now, $v_1^2/2g$ may be taken as a particular proportion of the head developed by the pump, say $s_c H_p$. Then we have:

$$s_c = (P_0/\rho g - P_1/\rho g + z_0 - z_1 - h_f)/H_p$$

or

$$s_c = (P_0/\rho g - P_1/\rho g + \Delta z - h_f)/H_p$$

where $\Delta z = z_0 - z_1$

For the prevention of cavitation at the inlet of the pump, P_1 must be greater than P_v, the vapour pressure of the liquid, i.e. $s > s_c$ where:

$s = (P_0/\rho g - P_v/\rho g + \Delta z - h_f)/H_p$ (2)

and s_c is the critical value of this parameter at which appreciable cavitation begins.

The numerator of the expression (2) is the Net Positive Suction Head (NPSH).

In PIPENET^{TM}, the supply reservoir may be considered the input node of the pump. In this case Δz and h_f become negligible, and the NPSH becomes:

$NPSH = P_0/\rho g - P_v/\rho g$

and the cavitation parameter:

$s = (P_0/\rho g - P_v/rg)/H_p$

In summary, the NPSH may be considered to be a safety factor indicating the "spare" head available to the pump above the head at which would cause cavitation. The cavitation parameter is an expression of the same, but as a proportion the pump head.

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LEADING THE WAY IN FLUID FLOW ANALYSIS

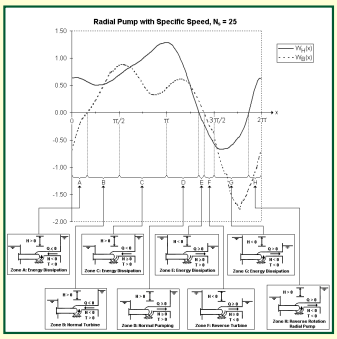
FREQUENTLY ASKED QUESTION

Question 11: In the Transient Module, why do I need to enter a Suter Curve for a turbo pump?

Answer: During a transient simulation, changing the operating condition of a pump may result in unsteady flow in a hydraulic system. This may be during normal start-up, normal shutdown, or sudden loss of power to the pump. Immediately after a pump start-up, the hydraulic system mostly experiences a local pressure rise, and immediately after a shutdown and power loss there is depressurisation. If pressures fall below vapour pressure, they may cause a growth and subsequently collapse of vapour cavities leading to a transient event. In the Transient Module, there are two types of pumps that may be used to simulate such a pump: a Simple Pump or a Turbo Pump. In circumstances where it is important to analyse unsteady flow caused by a pump, it is important to simulate the pump by a Turbo pump.

When such analysis is not as crucial, a Simple Pump is sufficient for the simulation and in most cases is perfectly adequate.

During a transient, a pump may experience a reversal in flow through the pump, or a change in its rotational speed, or both. Furthermore, it may also experience negative torque values and/or pressures during a transient event. Hence for accurate simulation of a Turbo pump, more performance data are needed and should cover regions of abnormal operation. Any unusual behaviour exhibited by the pump, even momentarily, may influence a transient event. These data may be presented graphically in the pump's corresponding Suter Curves. The curves express the head-flowrate, W_H and torque-flowrate, W_B for the turbo pump for all regions of operation, where the flow conditions (i.e. head, flowrate, speed and torque) are non-dimensional and expressed as percentages of the rated values: values at the point of best efficiency. A detailed description of the Suter transforms may be found in the Transient Module Technical Manual, Chapter 1, page 18.



Click diagram to enlarge

The figure shows typical Suter curves for a Radial Pump. The regions referred to in the figure are termed as Zones and Quadrants[1]. Each quadrant is of length $\pi/2$ and the zones lying therein are split at zero head-flowrate and torque-flowrate values. There are eight possible zones of pump operation: four occur during normal operation and four are abnormal zones. During a transient event, a pump may enter most, if not all, regions in the figure depending on the appropriate circumstances.

Normal Quadrant π - $3\pi/2$ Zone D represents the region of normal operation of a pump. All four quantities: head, H; flowrate, Q; pump speed, N; and, applied torque, T, are defined as positive. The head is defined to be the difference between the outlet and inlet values. The flowrate is defined to be positive if the fluid passes from the inlet to outlet. The pump rotational speed is defined positive in the clockwise direction as depicted and the applied torque is the difference between the motor torque applied by the pump and the fluid torque imparted on it. In this case, the flowrate is positive indicating useful application of energy. A machine can operate in Zone E if it is being overpowered by an upstream pump or reservoir or there is a sudden pressure drop during a transient event such as a pump trip. When in Zone F, it is likely but not useful that a pump may generate power with positive flow and pump speed due to the negative head and result in positive efficiency given the negative torque. The efficiency is low due to either poor entrance and/or exit flow conditions.

Dissipation Quadrant $\pi/2$ - π The pump usually enters Zone C shortly after a pump trip. Even if there is a downstream operating valve, the combined inertia of the motor and pump and its entrained fluid, may maintain a positive pump rotation but at a reduced value at the time of flow reversal due to the positive head on the machine. This may be momentary depending on the rate at which the downstream operating valve is closed. This zone is purely dissipative and results in negative or no efficiency.

Turbine Quadrant 0 - $\pi/2$ After completing Zone C, the pump may experience flow conditions of Zone B depending on the presence of a downstream operating valve. In this zone, the pump rotational speed is now negative forcing the pump to `run away' and the applied torque is positive. Even though the `run away' pump is not generating any power, it is precisely the same zone of operation of a hydraulic turbine with positive

values of head and torque but negative values for pump speed and flowrate. Zone A is encountered subsequent to a pump trip or a machine that has failed earlier. The difference between Zones A and B is that the sign of torque has changed, and hence the pump experiences a braking effect. This reduces the free wheeling nature of the pump. In fact, the actual `run away' condition of a pump is attained at the boundary of the two zones when there is no applied torque.

Reversed Speed Dissipation Quadrant $3\pi/2$ - 2π Zones G and H are very unusual and infrequently encountered in operation. Pumps that are designed to increase flow from a higher to lower reservoir, and are inadvertently rotated the wrong way may encounter these zones. Zone G is a purely dissipative zone. Zone H is the only zone to have different flow conditions depending on the type of pump used. A radial pump will produce positive flow with a considerable reduction in capacity and efficiency compared to normal pumping giving a positive head across the machine. Mixed and axial pumps create flow in the opposite direction and a head increase in the direction of flow.

As it is not always possible to obtain the complete Suter Curve from the manufacturer, one may model the pump as a typical, built-in radial flow, mixed flow or axial flow pump, depending on the pump Specific Speed, $N_S=N_R\ Q_R^{1/2}\ H_R^{-3/4}$, where $_R$ indicates rated values. It is possible to do so as pump's Suter curves tend to have similar shapes, for the same Specific Speed. Alternatively, the curve may be estimated by interpolation with the PIPENET^{TM} built-in curves.

If one would like to enter a user-defined Suter curve, one must first non-dimensionalise the physical quantities and apply the Suter Transforms. The abscissa, x ranges from 0 to 2π. If the flowrate is negative AND the pump speed is strictly negative, then x ranges between 0 and $\pi/2$; if the flowrate is strictly negative AND the pump speed is positive, then x ranges between $\pi/2$ and π; if the flowrate is positive AND the pump speed is positive, then x ranges between π and $3\pi/2$; and if, the flowrate is strictly positive AND the pump speed is strictly negative; then x ranges between $3\pi/2$ and 2π.

[1] *Martin, C. S., "Representation of Pump Characteristics for Transient Analysis", ASME Symposium on Performance Characteristics of Hydraulic Turbines and Pumps, Winter Annual Meeting, Boston, November 13-18, 1983, pp. 1-13*

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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

PIPENET™ STANDARD MODULE

- Description
- Key Features
- Case Studies
- Information Request

Description

The PIPENET™ Standard Module is a powerful tool in the design of general steady flow of fluids (liquids, gases and steam) in pipes. It provides a quick and cost-effective means of designing real life problems. This includes the design of pipe sizes in a network and the modelling of blocked or broken pipes in a network to create "what-if" scenarios.

Networks in the PIPENET™ Standard Module can be as simple or complex as necessary. A network can be defined from a wide choice of elements - pipes, ducts, nozzles, pumps, fans, filters, non-return valves, control valves, leaks, fixed pressure drops, orifice plates, properties and specifications. A network can be defined using either schematic or text input. However, a text-input network can also be displayed using the schematic. On-line help is also available for more information on the features of PIPENET™.

PIPENET™ has built-in data of fittings (Crane), gases, water properties, steam (IFC67 Standard) and pipe schedules (ANSI, JIS and DIN). Users can also create their own pump, pipe schedule, control valve, fittings and fluids data libraries that can be used in any network. The properties of the fluid can either be constant or variable.

Key Features

Fittings - Multiple fittings can be inserted on a pipe and it is not necessary to treat them as separate entities. They are simply defined as attributes of a pipe.

Schematic Capture Facility - A network can be defined using schematic and results can be displayed on the schematic. A properties window can also be displayed to the right of the schematic to display the properties of a component and any associated results. On-line help gives more details on the features of PIPENET™.

Pump/Fan - These can be connected in series or parallel at any point in the network. A pump/fan pre-processor can be

used to create libraries of performance characteristics. A graphical representation is also available for the pump data.

Pipe sizing and blocked and broken pipes - Having defined a pipe schedule to be used in a network, PIPENET™ can select the appropriate nominal bores during the calculation. A blocked or broken pipe can also be modelled in a network to analyse "what-if" scenarios. Cavitation - PIPENET™ will detect and report the likely occurrence of both deaeration and vaporisation cavitation.

Units - Instant conversion of input data to different units. This can be Metric, SI, British, American or User-Defined.

Orifice plates - Restriction orifice plates can be modelled in compliance with Crane, Heriot-watt and BS1042, taking into account the downstream pressure recovery. Given the pressure drop, the orifice diameter is determined, and vice-versa.

Leaks - This is useful for flow analysis of ventilation systems where the handling of leaks is very important. Leaks are modelled in accordance with the requirements of BS5588. Leaks may be defined as between two nodes of a network or to the atmosphere.

Output report - This can be created using Word, Write or PIPENET™ Output Browser. Meet mandatory requirements as PIPENET™ results are acceptable to regulatory authorities.

Case Studies

The following case studies describe typical real life applications of PIPENET Standard Module. Simply click on the example of interest for a detailed description.

Case Study 1: Design of a Modification to a High-Pressure Steam Utility System

Case Study 2: Design of a Cooling Water System

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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

PIPENET™ SPRAY/SPRINKLER MODULE

- Description
- Key Features
- Case Studies
- Information Request

Description

The PIPENET™ Spray/Sprinkler Module is specially developed for the design of fire protection systems in accordance with the NFPA and FOC rules. The PIPENET™ Spray/Sprinkler Module is ideal for all types of water-based systems. It can be used to design deluge, ringmain, sprinkler and foam solution systems for offshore platforms, refineries, petro-chemical and chemical plants.

Networks in the PIPENET™ Spray/Sprinkler Module can be defined from a wide choice of elements - pipes, nozzles, deluge valves, pumps/fans, filters, non-return valves, orifice plates, special equipment items, specifications and overboard dump valves. A network can be defined using either schematic or text input. However, a text-input network can also be displayed using the schematic. On-line help is also available for more information on the features of PIPENET™.

PIPENET™ has built-in data of fittings (complies with the NFPA rules), pipe linings and pipe schedules. Users can also create their own pump, pipe schedule, pipe lining, nozzle and deluge valve data libraries that can be used in any network.

The PIPENET™ Spray/Sprinkler Module can be run with several options for deluge and sprinkler systems. For example, the program can automatically identify the most remote nozzle and set its flow rate. The user may even specify the flow rate or flow density at a selected nozzle, or the available inlet pressure or flow rate. Orifice plates may be sized to balance the pressure required by the deluge system and the pressure available in the ringmain.

The PIPENET™ Spray/Sprinkler Module is ideal for firewater ringmains. Pumps may be connected in series or parallel anywhere in the network and they can be easily switched on or off at any time. Pump selection calculations may be carried out, or alternatively, manufacturer's data for pumps can be used. It is possible to perform case studies with different fire scenarios, model breaks and blocks in the network and use lined and unlined pipes in the same network.

Key Features

Fittings - Multiple fittings can be inserted on a pipe and it is not necessary to treat them as separate entities. They are simply defined as attributes of a pipe.

Schematic Capture Facility - A network can be defined using schematic and results can be displayed on the schematic. A properties window can also be displayed to the right of the schematic to display the properties of a component and any associated results. On-line help gives more details on the features of PIPENET™.

Pipe sizing - A powerful feature of PIPENET™. The user can leave some or all pipe sizes unset and PIPENET™ will automatically suggest appropriate pipe sizes based on the pipe schedule being used in the network.

Orifice plates - Restriction orifice plates can be modelled in compliance with Crane, Heriot-watt and BS1042, taking into account downstream pressure recovery. Given the pressure drop the orifice diameter is determined, and vice-versa.

Remote nozzle calculation - Calculations can match the minimum flow rate required at the nozzle that is hydraulically most remote. Nozzles can also be switched on or off. Materials take-off - Materials take-off tables can also be produced for weight and cost estimation purposes.

Units - Instant conversion of input data to different units. This can be Metric, SI, British, American or User-defined.

Deluge valves - This may be of conventional "clack" shut type or "constant flow" type. Monitors and hydrants may be attached anywhere in the network. Loops, grids and trees may be incorporated in any combination.

Output report - This can be created using Word, Write or PIPENET™ Output Browser. Meet mandatory requirements as PIPENET™ results are acceptable to regulatory authorities.

Case Studies

The following case studies describe typical real life applications of PIPENET Spray/Sprinkler Module. Simply click on the example of interest for a detailed description.

Case Study 1:	Analysis of a Fire Protection System
Case Study 2:	Design of a Fire Ringmain for a Gas Processing Plant

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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

PIPENET™ TRANSIENT MODULE

- Description
- Key Features
- Case Studies
- Information Request

Description

The PIPENET™ Transient Module provides a speedy and cost-effective means of in-house rigorous transient fluid flow analysis. PIPENET™ Transient Module can be used for predicting pressure surges, calculating hydraulic transient forces or even modeling control systems in flow networks. It is easy to use - users having little or no experience of the software can quickly set up even the most complex problems.

The PIPENET™ Transient Module can model networks with items such as pipes, pumps (simple and turbo), valves (operating, non-return, check, fluid damped check, liquid surge relief, regulator and inertial check), tanks (accumulator, simple and surge), caissons, vacuum breaker and control systems (pressure and flow sensors, PID controller and transfer functions to represent the dynamics of instruments and valves). The PIPENET™ Transient Module also has a model of a single compressible pipe. A network can be defined using either schematic or text input. However, a text-input network can also be displayed using the schematic. On-line help is also available for more information on the features of PIPENET™.

The PIPENET™ Transient Module has built-in data of fittings, pipe linings and pipe schedules. Users can also create their own pump, pipe schedule, pipe lining, and valve data libraries that can be used in any network.

PIPENET™ Transient Module allows users to specify the units in which data is to be entered, and for the output results.To reduce the time spent entering data, PIPENET™ Transient Module has been designed so that data for pipes, pumps and valves that is common to more than one problem (as is frequently the case) only needs to be entered once and can be replicated.

When solving problems, the engineer often wishes to experiment with different variables, such as valve and pump operating schedules. PIPENET™ Transient Module is specially designed to facilitate this: basic network information need only be specified once, and may be modified quickly and easily for subsequent simulations.

Key Features

Fittings - Multiple fittings can be inserted on a pipe and it is not necessary to treat them as separate entities. They are simply defined as attributes of a pipe.

Schematic Capture Facility - A network can be defined using schematic and results can be displayed on the schematic. A properties window can also be displayed to the right of the schematic to display the properties of a component and any associated results. On-line help gives more details on the features of PIPENET™.

Automatic Calculation of Wave Speed and Time Step. However, the user has the option to specify both the wave speed and the time step.

Cavitation Modelling and Boundary Conditions - Not only can PIPENET™ Transient Module predict cavity separation, it can actually model its formation and collapse. A wide choice of functions are available for setting up boundary conditions - constant, sine wave, damped sine wave, profile (linear, step or cubic), power ramp, exponential and asymmetric pulse.

Graphical, Forces and Tabular output - PIPENET™ Transient Module yields graphical and tabulated results of flowrates, pressures and hydraulic transient forces, as well as information related to network components, such as the settings of valves and the heights of fluids in accumulators. The graphs can also be viewed as movies in real time. Hydraulic transient forces can be output to a separate file, which can then be used by pipe stress analysis programs for further processing if required.

Initial Conditions - The PIPENET™ Transient Module can find its own initial and final steady states or use initial values supplied by the user.

Pumps - The pressure increase provided by a simple pump depends on its speed and performance curve. The speed can be specified directly or by a signal from the control loop. The turbo pump can additionally handle the 'spin down' due to pump failure. A graphical representation is also available for the pump data.

Control Systems - This allows components such as pumps or valves to react to changes in pressure or flowrate in some part of the network. A sensor measures an instantaneous reading for pressure or flowrate, which is converted to a signal for the controlled device by means of a PID controller. A transfer function in a control loop can model the dynamics of the sensor and the controlled device.

Water Hammer, Steam Hammer and Surge Analysis.

Meet mandatory requirements as PIPENET™ results are acceptable to regulatory authorities.

Case Studies

The following case studies describe typical real life applications of PIPENET Transient Module. Simply click on the example of interest for a detailed description.

Case Study 1: Surge Analysis in a Firewater Ringmain

Case Study 2: High-Pressure Steam Utility in a Power Station

Case Study 3: Pump Priming in an Offshore Firewater Ringmain

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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

CASE STUDY 1

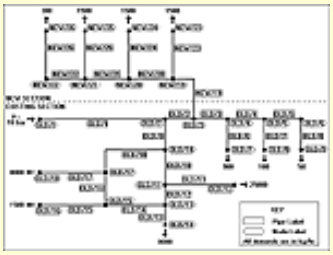
Analysis of a Refinery Problem using Standard Module

PIPENET™ Standard Module was used with outstanding success in the design of a modification to a High Pressure Steam Utility System in a Refinery.

The engineer often wishes to experiment with different variables, such as valve and pump operating schedules when solving problems. PIPENET™ Standard Module is specially designed to facilitate this: basic network information need only be specified once, and may be modified quickly and easily for subsequent simulations. The following example illustrates the use of the PIPENET™ Design Facility to find a solution to the problem.

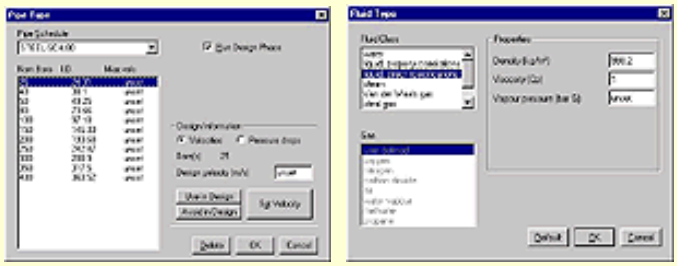
Problem - High Pressure Steam System

The Refinery was designing an extension to an existing system so that pipework would lead to four new outlets. The configuration is shown in the diagram below, with the existing network labelled with the tag 'OLD' and the proposed new section labelled with the tag 'NEW'. The problem was to find what the sizes of the new pipes should be in order to provide the specified supplies at the four new outlets. Steam was available at the header inlet at 18 bar gauge and 230° C. PIPENET™ Design Facility was used to choose the appropriate sizes for the pipes in the new part of the network.



Click diagram to enlarge

To facilitate data entry, the user interface is the Windows format, which customers consistently find straightforward to use. Data is entered into dialog boxes such as those shown below:

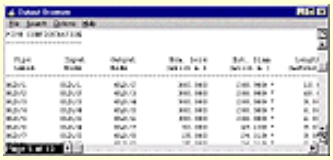


Click diagram to enlarge

The **Network** may consist of pipes, ducts, pumps, fans, check valves, control valves, nozzles, filters, orifice plates and other components. Fittings can be defined or selected from a list Control valves can be set for pressure, differential pressure, flow or valve position.

PIPENET™ can check for cavitation, correct for ambient pressure decrease with height, calculate hydraulic gradients and model leaks. The pipes available are entered in the Pipe Type dialog box. (above)

The **Results** of calculations are tabulated in the custom-made Output Browser (below). The range of possible output results tables is extensive, making PIPENET™ Standard Module a valuable tool when analysing networks.



Click diagram to enlarge

- Network data is quick and simple to enter.
- Windows format for data entry.
- Calculation time is short.
- Extensive component range.
- Tabulated results of calculations.
- Powerful analysis of networks.

Results of the Calculation

PIPENET™ Standard Module was used to investigate the pressures and flowrates in the pipes and fittings, and the pipe diameters required to provide the specified flowrates. PIPENET™ Standard Module allowed a thorough analysis of the problem, and the results were tabulated in the Output Browser. This shows clearly (4th column in the table above) that pipes NEW19 and NEW20 should be 100mm, NEW21, NEW22, NEW23 and NEW24 should be 80mm, NEW26 should be 40mm and NEW22 should be 25mm diameter.

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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

CASE STUDY 2

Analysis of Cooling Water System Problem using Standard Module

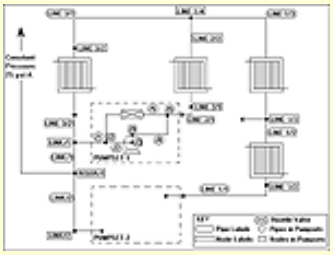
PIPENET™ Standard Module was used with outstanding success in the design of a cooling water system by a leading company.

The engineer often wishes to experiment with different variables, such as valve and pump operating schedules when solving problems. PIPENET™ Standard Module is specially designed to facilitate this: basic network information need only be specified once, and may be modified quickly and easily for subsequent simulations. The following example illustrates how quickly one can appraise a proposed solution to the problem.

Problem - Cooling System

Standard Module was used to help design a closed loop cooling water system, which circulated a glycol-water mixture through four heat exchangers. Two identical pump sets were used, each of which operated with local recycle and were controlled by a throttle valve. After passing through the heat exchangers the coolant streams were to be combined, chilled and returned to the recycle pump inlets.

It was necessary to find the flowrates at the pumps required if the pressure was to be maintained at 25 psi A at the riser. The pressures and the flowrates in the pipes were of particular importance, as incorrect flowrates might result in insufficient heat being removed from the heat exchangers.



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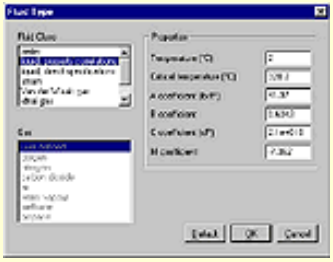
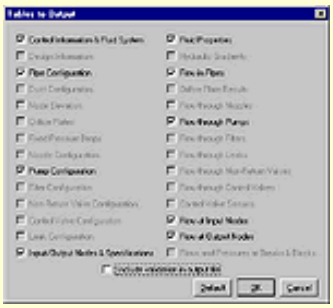




Click diagram to enlarge

The **Network** may consist of pipes, ducts, pumps, fans, check valves, control valves, nozzles, filters, orifice plates and other components. Fittings can be defined or selected from a list Control valves can be set for pressure, differential pressure, and flow or valve position.

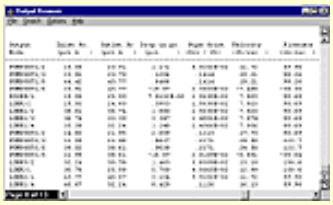
PIPENET™ can check for cavitation, correct for ambient pressure decrease with height, calculate hydraulic gradients and model leaks. The fluid is chosen from those available in the database of fluids, or can be added in the Fluid Type dialog box. (above)

The **Results** of calculations are tabulated in the custom-made Output Browser. The range of possible output results tables is extensive, making PIPENET Standard Module a valuable tool when analysing networks.

Results of the Calculation

PIPENET™ Standard Module was used to investigate the pressures and flowrates in the pipes and fittings, and the power required by the pumps. The Output Browser gives the required flowrate as 92.02 cuft/min by PUMPSET1/3, and and 117.8 cuft/min by PUMPSET2/3. The pressures and flowrates for the pipes are shown below. PIPENET™ Standard Module allowed a thorough analysis of the problem.

The Output Browser shows clearly that the pressure is highest at PUMPSET 1 with an inlet pressure of 44.42 psi A, and that the flowrate is highest (150.6 lb/sec) in LINE 3/1 and LINE 3/2. The friction in the pipes and fittings, and the resulting pressure drops are also given, suggesting to the engineer where possible improvements could be made in the network.



Click diagram to enlarge

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PIPENET™

LEADING THE WAY IN FLUID FLOW ANALYSIS

CASE STUDY 1

Analysis of a Fire protection system using Spray/Sprinkler Module

The PIPENET™ Spray Module is indispensable when designing a fire protection system for a tank farm. Foe example, if the intention is to protect each tank by a pair of external deluge systems. PIPENET™ Spray Module can be used to find the required diameters of the pipes in the system, and to determine the pressure and flowrate needed at the system inlet to ensure that all nozzles in the system discharged at or above the specified rate. PIPENET™ Spray Module is ideally suited to problems such as this.

Problem - Condensate Tank Deluge System

If an Engineer wishes to ascertain the pipe diameters that would produce the desired flowrates at each Elevation of a single tank nozzle, and also the pressure and flowrate needed at the system inlet to ensure that all nozzles in the system discharged at or above the specified rate. Say, each deluge system consists of three horizontal semicircles, spaced at 3.28m intervals vertically. Each semicircle has 12 nozzles: 6 on each side of the vertical feed pipe. Each tank has two such semicircular deluge systems. An elevation view of a tank is shown.

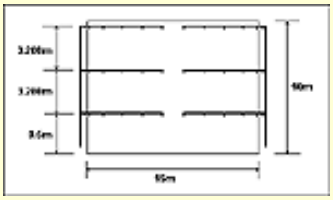


Fig1. Elevation of a single tank

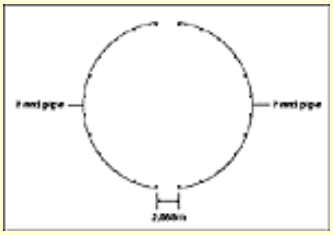


Fig 2. Plan of a single deluge ring

Click diagram to enlarge

The pipe diameters are found using PIPENET Spray Module in the Design Plan of a single deluge ring facility, where it is assumed that each nozzle is discharging at a rate of 65.4498 litres/min. The design velocity is 4m/s for all pipes.

The 'Most Remote Nozzle' option is used to set the furthest nozzle supply rate as the required rate, which causes the other nozzles to supply water at a slightly higher rate.

Data Entry using the Windows Interface

The nozzle type is defined in a dialog box by its k-factor and its minimum and maximum pressures. Several different types of nozzle may be entered into the nozzle library, and then used when entering the configuration of the network.

PIPENET's Design Facility requires a list of available pipes to be entered into the appropriate dialog box. In order to provide accurate solutions, the internal and external diameters are required, as well as the nominal bore size.

Fig 1. The Initialisation dialog box

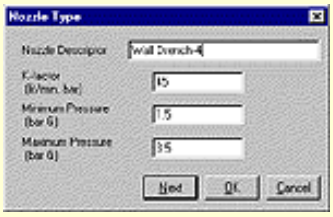


Fig 2. The Edit Nozzle dialog box

Click diagram to enlarge

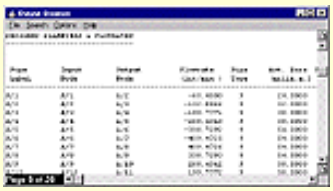
The Initialisation Options dialog box is used to define the fluid properties, and specify that the Hazen-Williams equation should be used to model pressure drops. The 'NFPA' option is also chosen, to ensure that the NFPA rules for fittings friction losses are satisfied in the solutions generated by PIPENET Spray Module.

The Edit Nozzle dialog box allows the user to specify the positions of the nozzles and the flowrates through them. The nozzle properties are stored in the Nozzle library, so they only need to be defined once. To save time when entering many identical nozzles, the 'Rept' button copies all of the data of a nozzle into the next nozzle definition box so that only the inlet node and label need to be entered in order to define the next nozzle.

- Network data is quick and simple to enter.
- Calculation time is short.
- Modifications to simulations are easy to make.
- The range of network features that can be modelled is

extensive.
- Automatic check facility allows user to verify that data entry is correct.
- Results of calculations are tabulated .

The calculation results as viewed in the output browser show that the Pressure required at the inlet of each deluge system would be 3.584 bar gauge, and that the Flowrate there should be 2692 litres/min. It also tabulates the flowrates through the individual nozzles, and gives the percentage deviation from the design flowrate of 65.45 litres/min. Total lengths of each pipe bore required is also listed, for example: 18.61 metres of the 50mm nominal bore pipe were required for each deluge system.



Click diagram to enlarge

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LEADING THE WAY IN FLUID FLOW ANALYSIS

CASE STUDY 2

Design of a Fire Ringmain for a Gas Processing Plant using Spray Module

The PIPENET™ Spray Module played an integral role in the design of a fire ringmain for a Gas Processing Plant feeding a number of potential fire-hazard areas. The system was to be designed to protect five zones, and an investigation into how the supply requirement could be met by a pump was required.

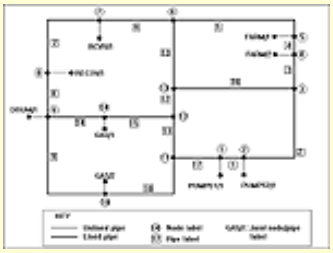
PIPENET™ Spray Module was used to find the required diameters of the pipes in the system, and given that a pressure of 3.52 gar gauge was required at one of the inlets, to find the pressure required at the pump outlet in order to provide this.

Problem - Ringmain Pressures

The engineering company wished to ascertain the pressure required at the outlet of PUMPS2/1 in order to provide a pressure of 3.52 bar gauge and a flowrate of 5364 litres/min at FARM/2. Only one of the zones would be discharging at any given time, but the system had to be designed to cater for flow through any of them. PUMPS2/1 would produce too high a pressure at the inlet to FARM/2, so the size of the orifice plate at the inlet to FARM/2 needed to reduce the pressure to 3.52 bar gauge was required.

The pipes in the primary main (below) were to be below ground and lined with 2mm thick cement, with a C-factor of 90. In the scenario that was modelled, only PUMPS2/1 operated. The pressure produced by the pump was required by, as well as the required size of orifice plate at the inlet to FARM/2.

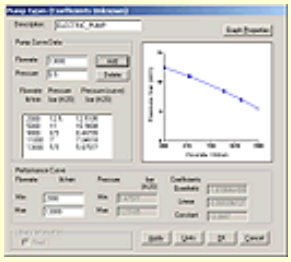
PIPENET™ Spray Module was used to perform calculations for the other outlets in a similar manner, but only the analysis for FARM/2 is documented here.



Click diagram to enlarge

Data Entry using the Windows Interface

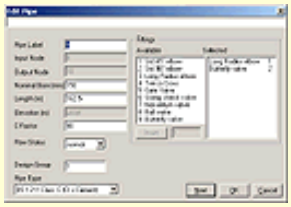
The performance coefficients of the pump were unknown so it was necessary to enter coordinates from the performance curve into the **Pump/Fan** dialog box.



Click diagram to enlarge

The pre-processor found the coefficients using regression.

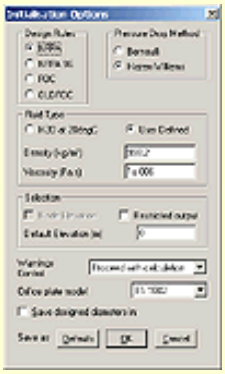
The configuration of pipes was enteredinto the **Edit Pipe** dialog box, where the pipe bore, length, C-factor, material and liningwere entered. PIPENET™ Spray Module works with the internal and external pipe diameters, but pipes are defined by their nominal bores.



Click diagram to enlarge

Fittings could be included on each pipe, such as the Long Radius elbow and the Butterfly Valve on the pipe shown.

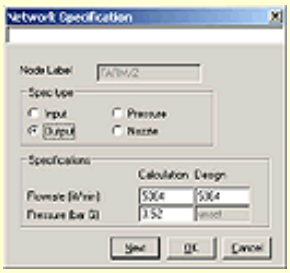
The **Initialisation Options** dialog box was used to define the fluid properties, and specify that the Hazen-Williams equation should be used to model pressure drops. The 'NFPA' option was also chosen, to ensure that the NFPA rules for fittings friction losses were satisfied in the solutions generated by PIPENET™ Spray Module. The default values held by PIPENET for the density and viscosity of water were chosen.



Click diagram to enlarge

The **Network Specification** dialog box was used to enter

network information, such as flowrates out of nodes. In the case for FARM/2, shown, the section being supplied by the pump in this simulation, the flowrate was set to 5364 litres/min and the pressure was set as 3.52 bar gauge.



Click diagram to enlarge

Results of the Simulation

The Output Browser stated that in order to produce a pressure of 3.52 bar gauge at the node FARM/2, with a flowrate of 5364 litres/min, a pressure of 5.752 bar gauge was required at PUMPS2/1 outlet.

When the pump was added, a pressure of 8.542 bar gauge was produced at the node FARM/2. In order to reduce this pressure to the required pressure of 3.52 bar gauge, an orifice plate was added to the pipe FARM/2. This was done using the Orifice Plate option from the View menu in Windows. The pressure drop required across the orifice plate was (8.542 - 3.52) = 5.022 bar. This formed part of the data for the orifice plate.

Given this pressure drop, PIPENET™ Spray Module sized the orifice and reported in the Output Browser that it should have a diameter of 69.3567mm.

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LEADING THE WAY IN FLUID FLOW ANALYSIS

CASE STUDY 1

Analysis of an Offshore Firewater Ringmain Problem Using Transient Module

PIPENET™ Transient Module has been used with outstanding success for an Offshore Firewater Ringmain project contracted to a leading company. One of the most important considerations of the project was an analysis of the pressure surge resulting from closure of the monitor valves. PIPENET™ Transient Module had a unique role in this project.

When solving problems, the engineer often wishes to experiment with different variables, such as valve and pump operating schedules. PIPENET™ Transient Module is specially designed to facilitate this: basic network information need only be specified once, and may be modified quickly and easily for subsequent simulations. The following example illustrates how quickly one can appraise a proposed solution to a problem.

Problem - Surge Analysis in Firewater Ringmain

One of the things the engineers wished to investigate was related to the surges that were expected to occur in a firewater ringmain when the monitor valves were closed. Two scenarios were simulated. In both scenarios the overboard dump valve and deluge valve remained closed and the fire pump operated at full speed throughout supplying the helideck with water through the firewater/foam monitors, which were initially fully open. In the first case the monitors closed linearly over 1 second: the first between 3s and 4s, and the second between 13s and 14s. In the second case the monitors closed linearly over 3 seconds in an attempt to reduce the surge created by their closure: the first between 1s and 4s, and the second between 11s and 14s.

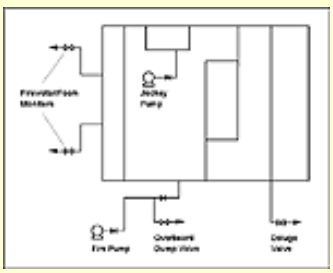

Fig 1.The network schematic

Click diagram to enlarge

The Windows format facilitates data entry by using dialog boxes.The valve closure schedule is changed in the

Specifications dialog box (below). This is a simple procedure, which makes the testing of different valve schedules quick and simple to perform.

Fig 2. The Specification dialog box

Click diagram to enlarge

The data specifying the fluid properties is entered into the Fluid dialog box (below). Another dialog box offers the user the opportunity to include cavitation effects.

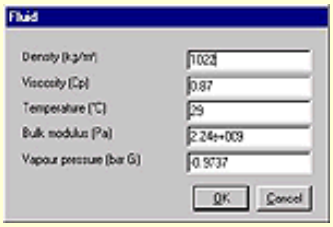

Fig 3. The Fluid dialog box

Click diagram to enlarge

Results of the Simulation

Surges occured at the monitors when the valves closed, which resulted in oscillations in pressure through the network. The graphs of the flowrates through the monitors show that when monitor 1 closes, there is a rise in the flowrate through monitor 2. When monitor 2 closes, there is no alternative outlet for the water, which explains why the pressure surge caused by its closure is larger than that which results from the closure of monitor 1. The graphs illustrate that when the monitor valves closed over 3 seconds the amplitudes of the surges and oscillations were dramatically reduced: the maximum pressure was about 22 Bar G when the monitors closed in 1s, but only about 11.5 Bar G when the monitors closed in 3s. More accurate values of these maxima could be read from the output data document. Thus a reliable and effective monitor valve closure schedule was found with the aid of PIPENET™ Transient Module.

Click diagram to enlarge

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LEADING THE WAY IN FLUID FLOW ANALYSIS

CASE STUDY 2

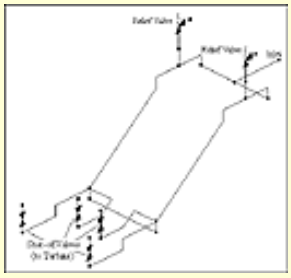
Analysis of High-Pressure Steam Problem using Transient Module

PIPENET™ Transient Module was used with outstanding success for a project contracted to a leading company. One of the main components of the project was to design a safe and reliable valve closure system for a high-pressure steam network in a power station. PIPENET™ Transient Module had a unique role in this project.

Transient Module is ideally suited to problems such as that described below. Its capabilities range far beyond this simple case.

Problem - Steam Hammer

High-pressure steam enters from a boiler and runs to four shut-off valves, which lead to turbines. The objective of the analysis was to investigate the effects of closing these valves quickly in an emergency to isolate the turbine. To relieve pressure surges in the network, two relief valves could open if a specified pressure limit was reached. Three scenarios were considered in an attempt to find a valve-closing pattern that did not cause an unacceptable pressure surge when the shut-off valves closed or result in a 'steam hammer' phenomenon. After this, the dynamic force results were input to a pipe stress analysis program.



Click diagram to enlarge

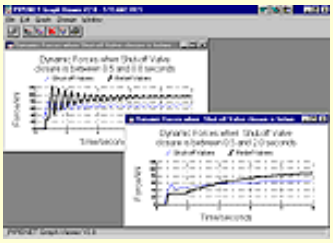
The Windows format means that data entry is facilitated by dialog boxes such as those shown below.

The user specifies the units in which data is to be input, and the units in which the output results appear (below left). The valve closure pattern can easily be changed in the Specifications dialog box (below right) between different simulations.

Click diagram to enlarge

Results of the Simulation

The simulations in this application show that the ‘steam hammer’ phenomenon is observed when the shut-off valves close linearly between 0.5 and 0.8 seconds, and that the linear valve closure between 0.5 and 2 seconds reduces these force fluctuations significantly.



Click diagram to enlarge

This is because the shut-off valves are still in the process of closing when the pressure wave arrives at the shut-off valves from the relief valves, so the pressure wave that occurred in the former case is not reflected back. Increasing the valve closure time has almost halved the force peak that arises at the shut-off valves.

Thus a reliable and effective mode of shut-off valve closure has been found with the aid of PIPENET™ Transient Module. Further valve closure patterns could be investigated using PIPENET™ simply by changing the specifications of the shut-off valve.

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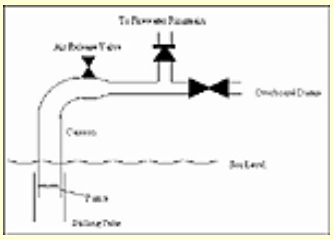
CASE STUDY 3

Analysis of a Pump Priming Problem using Transient Module

PIPENET™ Transient Module was used with outstanding success for an Offshore Firewater Ringmain project contracted to a leading company. One of the most important considerations of the project was the Pump Priming during routine weekly testing.

Problem - Surge Analysis in Offshore Fire Pump Priming

The situation under consideration is the weekly testing of the fire pump, which supplies a firewater ringmain on an offshore platform. A stilling tube surrounds the pump and protects it from pressure changes occurring in the sea. The caisson is initially full of air, and the valve to the firewater ringmain remains closed throughout. When the fire pump is started up, water rises up the caisson and expels the air from the system.



Click diagram to enlarge

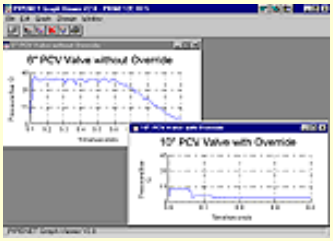
When all of the air has been expelled from the caisson and the air-release valve closes, all the water will have to escape through the Pressure Control Valve (PCV) back to the sea. While the air in the caisson is being expelled, the pump faces little resistance and so the momentum of the water is high. Thus care must be taken in the design of the overboard dump valve system to ensure that high pressure surges do not occur when the high momentum water hits it. Simulations modelled PCVs of diameters 6" and 10", with an optional override facility. The intention was that the latter would keep the PCV fully open while the pumps started up in order to reduce the anticipated pressure surge.

The Windows format facilitates data entry by using dialog boxes, such as those shown below for the Caisson data:

Click diagram to enlarge

Results of the Simulation

The results show that the pressure surges caused by the 6" PCV are alarmingly high. The surge is reduced when the manual override used because the water pumped up through the caisson can pass straight through the open PCV back into the sea. The pressure surge is significantly reduced by using the 10" PCV because the water that has been pumped up through the caisson can pass straight through the open PCV back into the sea. The build-up of momentum has less effect on the larger valve because this permits a greater flowrate, and so this is the recommended choice for the system.



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